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THE ROMANCE OF FISH LIFE

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THE CUTTLE RETREATING BEHIND A SMOKE SCREEN

THE ROMANCE OF FISH LIFE

By

W. A. HUNTER

AUTHOR OF "FISHERMAN'S KNOTS AND WRINKLES."
EDITOR OF "FISHERMAN'S PIE"

WITH SIXTEEN
FULL-PAGE ILLUSTRATIONS FROM PHOTOGRAPHS,
A FRONTISPIECE IN COLOUR AND
THIRTEEN LINE DRAWINGS

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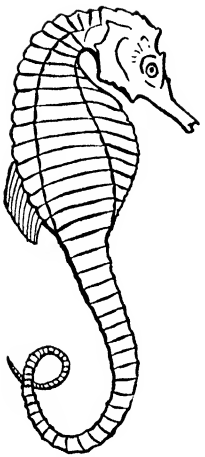
PREFACE



THIS book contains the substance of a series of lectures which the writer has delivered in many different parts of the country and to widely varied audiences — from schools to large public gatherings. The grouping of the subjects is indicated in the table of contents, where the titles of the lectures have been retained for the convenience of those who have heard them, and if there appears to be some overlapping in this arrangement there is an avoidance of duplication.

On many occasions at the conclusion of the lectures I have been asked if they were available in printed form, or if certain sections, such as the "Life History of the Salmon" or the story of the eels, were procurable in pamphlet form, and this volume is the response to these requests. It is hoped that these simple talks will be the means of stimulating interest in, and the desire for greater

knowledge of, some of the living creatures that inhabit the greatest of all haunts of life.

My thanks are due to many friends for valuable assistance, and especially to Mr. H. H. Goodchild, who drew or photographed most of the illustrations, and whose skill in that direction is obvious. The drawings were made from actual specimens, and are free from artificial embellishments and unnatural poses.

W. A. HUNTER.

BIRMINGHAM, 1931.

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FOREWORD

By PROFESSOR J. W. CARR, M.A., F.L.S., F.G.S.

Emeritus Professor of Biology in University College and Director of Wollaton Hall Natural History Museum, Nottingham

Books dealing with the characters, habits, and life histories of British and other fishes are innumerable, but there is, nevertheless, a great deal of out-of-the-way knowledge of the highest interest alike to the naturalist and to the " man in the street " which is not readily accessible. For this reason Mr. Hunter's fascinating little book is very welcome. It is full of curious information about fishes and fishing: the nest-building achievements of the stickleback and other species; the wonderful homing instinct of the salmon; the extraordinary and romantic life history of the eel; how to tell the age of a fish; the problems of deep-sea life; the harvest of the sea and the various ways in which it is gathered in—all these and many other matters are dealt with in a lucid and entertaining way. Many besides myself who have listened to Mr. Hunter's delightful lectures—and still more who have not enjoyed that privilege—will be glad to have them in so convenient and readable a form. Numerous woodcuts and full-page plates add to the value of the work, which should have a wide circulation.

Nottingham,
March, 1931.

THE ROMANCE OF FISH LIFE

CHAPTER I

PERSONALITY UNDER WATER

WHEN we remember that more than half of the earth's surface is covered by water we need not be surprised at the statement that there is greater variety as well as greater extent of animal life under water than there is on land. That being so, there must be, as of course there is, much in the character and habits of land animals, with which we are familiar, that can be found duplicated in the sea; indeed, there is scarcely any kind of profession or occupation followed by man himself that we could not find in greater or lesser degree followed by animals under water.

Engineers? Compare the greatest feats of human engineering work of ancient or modern times with the great coral reefs made by one of the humblest of sea animals, the coral polyp. Reefs like the great Australian Barrier, for instance, that stretches for a thousand miles, and behind which great harbours have been built, great fleets found shelter, a nation's sea-borne commerce made safe and secure.

Travellers? The common eel starts out on a three years' journey as soon as it is born, and without compass or even a "star to guide" finds its way across thousands of miles of ocean to fresh water, where it may grow to maturity. When the call of maturity comes, the eels reverse their direction and find their way back to their home in the southern seas.

Surgeons? The common shore crab, liable to accident in stormy weather, can amputate its crushed limb and grow another: the sea cucumber, when it cannot get rid of serious indigestion, gets rid of its stomach and grows a new one! The Amœba has an infallible remedy for obesity!

Electricians? Some of the rays and eels can produce powerful electric discharges from their bodies. This converting of potential energy into moving force is unknown among animals much higher in the scale of life.

Sanitary Officers? The American army authorities during the Great War called to their aid a small minnow in their fight with the malaria mosquito, and many a mosquito traitor was captured and killed by these little fish whose name is a Spanish word meaning "of little account."

Soldiers? The herring schools are marshalled in the recruiting grounds, and their migrations ordered, by commanders of such legions as "Cæsar never knew." The marshalling and controlling of the herring shoals is on a scale that baffles the

imagination and has so far defeated all our attempts at explanation or even understanding.

And then there are cardinal-fish, monk-fish, angel-fish, devil-fish, dog-fish, cat-fish, sea-mouse, sea-cow, sea-lion, sea-horse, and so on, for the examples could be greatly extended; but let us approach the subject with becoming humility and learn what we can of the lives and habits of some of the inhabitants of the water-world.

A fish has been described as a slippery animal that lives in water, and that leaves room for infinite variety in shape, size, colour, habits and peculiarities. Some are gregarious, some solitary; some plebeian, some aristocratic; some independent, some fond of frequenting the society of others larger or stronger than themselves for the sake of benefits to be received (a trait not unknown on land!). Some are faithful to their kind, some eat their own relatives; some are dainty, some will swallow anything; the variety is infinite.

One can trace human-like qualities in many of the fish, and probably that accounts for some of their names. Some are wise and some foolish, some care for their offspring and many neglect it, some are cultivated and others are mannerless, some proud and some humble, some loving and some unlovable, some courageous and some fearful.

Congestion, especially in shallower waters, inevitably leads to jealousy, competition, struggle, cunning. The stronger eat the weaker, the larger

destroy the smaller, the swifter steal from the slower. Nature provides for the masses, not for the individual; the eggs of most fishes form ingredients in the sea-soup which nourishes all animal life in the sea.

Far back in human history man regarded the lower animals as morally and intellectually his equals, a belief that gave rise to countless legends, fables and superstitions.

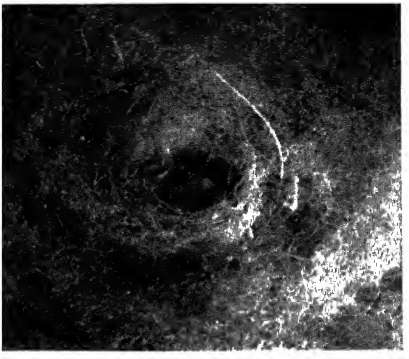
But with the advance of civilisation these lower animals became despised and were denied all consciousness or finer feelings.

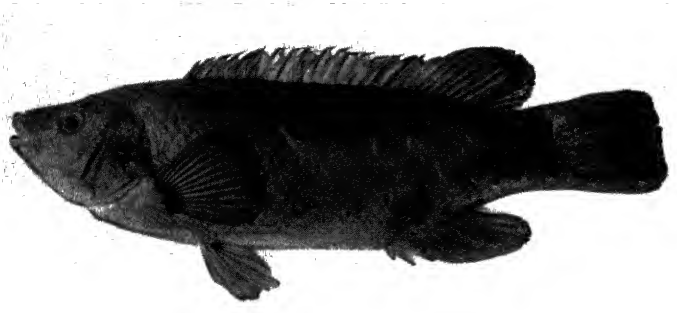
This error is now in process of correction, and no one will deny that some animals have senses of which we know little or nothing—a sense of locality, for instance, that is as wonderful as it is inexplicable.

The Stickleback, Nest Builder and Faithful Parent (Plate I)

The "tiddler" of our London waters, but called in other localities "prickle fish," "sharplins," "barnstacles," and "bandies," is one of the commonest and most widely distributed of British fishes, and is equally at home in fresh or in salt water. His full name is the three-spined stickleback (*Gastrosteus aculeatus*), and he has lesser-known relatives with greater numbers of spines. The stickleback is one of the few fishes that exercise parental care

PLATE I





NEST OF THE THREE-SPINED STICKLEBACK
A MARINE NEST BUILDER: THE BALLAN WRASSE

over their young, and one of the most skilful of the nest builders.

In spring the male assumes the task of nest building, and having found a suitable site, has often to defend it against rivals with all the pugnacity he possesses, and that is a good deal for his size. Collecting the necessary material in the form of weed debris, etc., he forms with the aid of a gummy secretion a sort of sugar-loaf-shaped nest, open at one end, closed at the other, smooth inside and rough on the outside, just like a bird's nest. That takes many days, and the work is rendered all the more arduous by the absence of any assistance from a mate and by the presence of jealous rivals. All this time, too, he is improving his own appearance, with the result that when the home is completed he is very gaily attired and ready to entice a mate to come and share it. His breast is now bright scarlet, his back olive green, and his spines shiny and sharp. If his efforts to entice a mate by peaceable means are unavailing, that is where the spikes come in useful, for a dig from them, or a nip from his sharp teeth, will serve when persuasion fails! When at last he succeeds in getting his mate to the nest, he may have difficulty in inducing her to enter, and will himself go in and out time after time, in order to assure her that there is no danger. When once she is inside he remains on guard, reminding her by taps on her tail with his under jaw that it is eggs he wants. The female stickleback seems to avoid

meeting her lord and master again, and pushes her way through the hitherto closed end of the nest to freedom. The male remains by the nest, keeping up for long spells a fanning motion with his large pectoral fins at the entrance of the nest; and this keeps a stream of fresh aerated water running through the nest, so that the embryos and the fry when hatched may receive the oxygen required for life and growth. For some days, and until they are able to look after themselves, the father remains in close attendance on his numerous family, but they soon scatter and father's life's work is accomplished. When newly hatched the stickleback is just about ¼ inch long and a very beautiful little creature; it grows rapidly to maturity, feeding on microscopically small animals and plant cells in the water, darting hither and thither in search of its food, which is too small for the human eye to detect. Soon it needs something more substantial, and small worms or insects are not despised.

Marine Nest Builders

The Ballan wrasse (Plate I) makes a nest of sea-weed wedged into a crevice in the rocks between tide levels. The eggs adhere lightly to the sea-weed, and the young when hatched are well advanced, the yolk sac being nearly absorbed.

The wrasses are for the most part tropical fish, but some of them range into temperate zones; they

are of little value commercially, having too many bones to be suitable for human food, but they give sport to the rod-and-line fisherman, and are appreciated by the longshoreman as bait for lobster pots. They are often very brightly coloured, and the sexes are so distinct that they have often been considered separate species.

Both the male and female take part in constructing the nest and in guarding the newly hatched young, which are coloured green and olive, shading to yellow underneath.

The food of the wrasses consists mostly of small crustaceans and molluscs, so the fish have been provided with powerful teeth in mouth and throat accordingly.

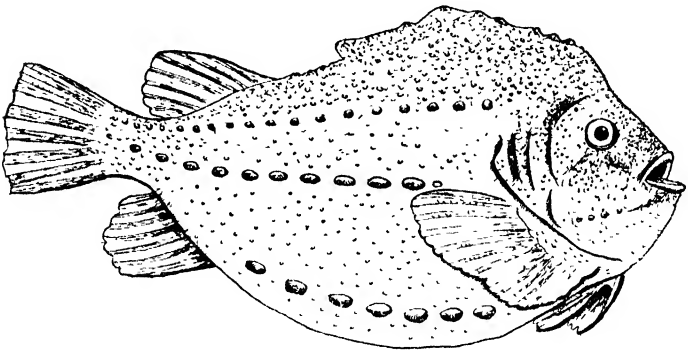
The fins are worth noting : the dorsal long, with stiff spiny rays in front and soft branched rays behind. The anal fin also has stiff spines in front.

The Lumpsucker

Although he does not provide a nest and is not favoured with good looks, being one of the ugliest of all fishes, the quaint lumpsucker is also a devoted parent. Perhaps the ugliness is a defence against his enemies, for the rough, warty skin is certainly not tempting in appearance. In course of development the hind (pelvic) fins have been moved forward and turned into a strong sucker, by means of which the fish can hold on to a rock or stone

whilst paddling vigorously with its tail; this habit is probably the origin of the Scottish name for the fish—*i.e.*, cock-paidle or paddle-cock.

The lumpsucker lays a big bunch of reddish eggs in a corner of a rock pool on the shore, and over this mass the father mounts guard, driving away intruders, aerating the eggs and brushing off foreign matter with his "paddling."



The Lumpsucker.

So intent on this duty is the lumpsucker that he is said to neglect his own food during the period, several weeks, of incubation.

A case is quoted by McIntosh where a lumpsucker had attached the eggs to a stone just above low-water mark; the stone, however, was partially covered at low tide, as it was situated in a run of water. At every low tide the body of the fish was only partially covered, and its gills were half out of water: the hot June sun made the fish very un-

comfortable, and though he was panting he never deserted the eggs.

To test the strength of this parental instinct the fish was removed a couple of yards, but at once wriggled back to its original position with its snout almost touching the stone to which the eggs were attached.

Parental care of their young is not common among fishes, however, but, when exercised, some of the methods are interesting.

The Sea-Horses

The sea-horses, that look so much like knights in a set of chessmen, but are true fish, are widely distributed, especially where the marine vegetation grows thickly. The sea-horses cling to bits of grass or weeds by their prehensile tails, and frequently swim about in pairs, linked together by their tails. The eggs are placed by the male in a brood pouch which he wears in front, slightly below the dorsal fin, and when they hatch the commotion inside the pouch causes a rapid contraction of the body in that region; this movement opens the pouch so that the young can escape, when they immediately begin to swim about by means of their rapidly vibrating dorsal fins. The young, when first free, are only about $\frac{1}{4}$ inch long, but are perfectly formed; their food consists of small living animals such as daphnia, cyclops, the larvæ of water

insects, and any living creatures that are small enough to pass the narrow mouth opening of the little fish. In the same family as the sea-horses, equally curious in appearance and with somewhat similar habits, is the pipe-fish, whose brood pouch is near the tail and causes him to seem as badly balanced lengthwise as the flat fishes are sideways. Some of the pipe-fishes are very similar in shape and colour to stems of sea-weed, and they have the faculty of adapting their colouring to their surroundings so closely as to render themselves almost indistinguishable from the weeds.

There is a little Indian fish, highly coloured and bearing the high-sounding name of *Trichogaster lalius*, which makes a very curious nest of plant fragments and air bubbles. After collecting the leaves, etc., on the surface of the water into a small heap, the fish takes in a mouthful of air at the surface and blows it out underneath the nest in small saliva-covered bubbles which are accumulated until the whole rises about $\frac{3}{4}$ inch above the surface of the water; from the edge of the bubble heap plant shreds hang downwards to form a fringe or rim round the airy nest.

The eggs are laid under the nest and float up into it, the male fish in the meantime remaining on guard to make any necessary repairs to the nest and to replace any eggs that may fall down. In the high temperatures generally prevailing where this fish lives, the period of incubation is short, and fre-

quently the eggs will hatch in twenty-four hours. During the first few days the male protects the young, but allows the nest to disintegrate.

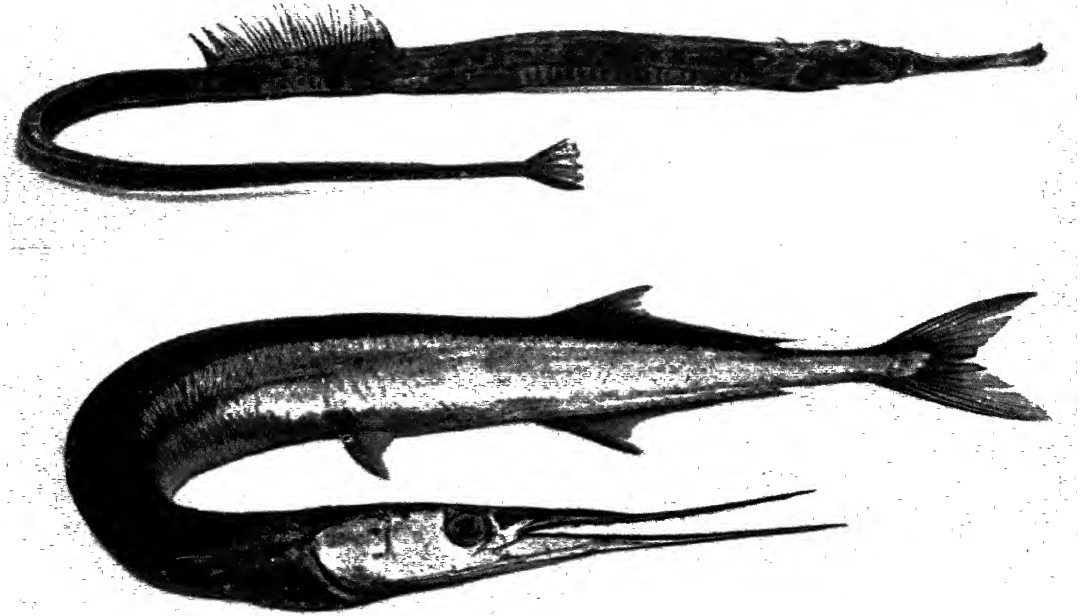
Some of our common shore fishes, such as the blennies and the gobies, take pains to fix their eggs to the insides of empty shells, and the under-sides of stones or ledges and similar places, by covering the eggs all over with a sticky secretion which soon hardens and forms a secure fastening. These little fish, which inhabit rock pools and shallow water, often display considerable care for their young in guarding the nesting places and the eggs at the risk of their own lives.

The mouth breeder (*Paratilapia multicolor*) takes care of its eggs and young in a peculiar manner, and it is probably the most interesting of all aquarium fish. It is a native of Egypt and may still be found in small ditches about Alexandria. The eggs are first laid in a narrow trench made in the sand where they are fertilized; the female then takes the eggs into her mouth and carries them there for a period of about fourteen days until they hatch. When they burst their protecting shells the young leave their peculiar shelter and swim about freely, returning to it on any sign of danger, the mother being always at hand ready to receive them into safe keeping again. During all this time the mother fish has taken no food and is in consequence very hungry; in such circumstances accidents *will* happen, and a tiny bright object darting about within reach may be

too great a temptation, for the mother can't stop to make sure that it isn't one of her own children; so it is better to remove both father and mother from the aquarium as soon as the little ones are able to swim freely.

Viviparous Fish

Some, but not many, of the bony fishes are viviparous (the young being carried in the mother until they are capable of feeding and protecting themselves). A little fish of the southern States of America has within the last twenty years or so forced itself into the public gaze, and has come to be recognised as an old but newly appreciated agent for public health. This little fish is called Gambusia, from the Spanish, and meaning "of no account," and was only used as a bait for perch, etc. In their investigations into the "environmental associations" of the immature malaria mosquitoes, scientists found that where the mosquitoes abounded there also were to be seen numbers of this gambusia; and it seemed strange that this little fish, with undershot jaw for surface feeding, should allow such a handy and attractive morsel of food to remain alive or in such numbers that the adult winged insect could ever result. However, the long warfare between these aquatic neighbours had taught the mosquito children that their lives depended upon their ability to lie alongside, under or upon a bit of floating leaf, weed or debris, and thus the destruction of the mosquito



WHY SMOKE A HADDOCK, WHEN THERE ARE THE PIPE-FISH AND THE MILD SEA-GAR?

PLATE II

by the fish had been counterbalanced by natural protection. Experiments proved that the minnow could be utilised as a mosquito control agent by modifying the conditions against the insect and in favour of the fish in several ways, such as cutting the protecting weeds, removing floating material, providing additional sandy shallow margins, etc., and so the little fish has come into its own as an active agent for public health. Its services were utilised during the war, and doubtless many a malaria mosquito traitor was taken prisoner by these active sentries and many an American soldier's life saved thereby.

The Sea-Gar and the Pipe-Fish (Plate II)

The oddly shaped gar-fish, like most of its tribe, which includes the pike, has generally been looked upon as vermin to be exterminated in any and every possible way, but has now also come to be recognised as of value to mankind in an indirect way. It appears that the posterity of a certain mussel, one of the most valuable of the many species of American fresh-water clams, depends on the despised gar-fish. This mollusc, the yellow sand shell from which pearl buttons and knife handles, etc., are made, cannot propagate itself without the gar, which nurses the baby shells as parasites until they can take up their independent existence on the bottom in competition with the other animals there. Our fresh-water mussels make use of minnows in

a similar manner, in order to give its young a safe resting place until the shells develop sufficiently. The eggs of the gar-fish are deposited in shallow water, and are attached by long adhesive filaments to each other and to sea-weed and other objects; after an incubation period of about five weeks larvæ about ½ inch long are liberated and are well developed, the lower jaw being already prominent. The young remain in shallow water during the first summer, and the lower jaw continues to lengthen until the fish are about 2 inches long, when the upper jaw begins to grow forwards.

Pike (The Water Wolf)

Esox lucius is a member of a large family, which includes the pipe-fishes, and has a wide distribution over Europe as well as over North America.

From the angler's point of view the pike is the biggest, most important, and most widely distributed of all the so-called "coarse" fish. That term is not a happy one, but it marks a well-recognised division between the "game" fish, such as the trout and salmon, etc., and the general fresh-water fish, such as the roach, bream, chub, pike, etc.

Pike may be found anywhere: in the still waters of reservoirs, ponds and lakes, and in the running waters of rivers, streams and canals; indeed, there are few districts in the British Isles where pike are not to be found.

The pike is a tyrant and knows only the laws of

might. Its food, broadly speaking, is anything that is alive and small enough to be swallowed or bitten into, even its own descendants. When fish cannot be obtained, or when a change of diet is preferred, pike will eat young ducks and other water-fowl, water-voles and any warm-blooded animals that frequent its territory. In the spring, when frogs are spawning, pike search for them, and no doubt tadpoles, newts, shrimps and other water creatures will be eaten by these, the most predacious of all British fresh-water fishes.

The age and size which pike attain is a matter of uncertainty, but in these islands a 20-pounder is a big fish. So much depends, however, on the amount and quality of the food available, for, although the 20-pounder is rather uncommon, and when caught may be fifteen years old or even more, I have seen pike of that weight that were not more than ten years old. In such favourable circumstances where there is an abundance of food and where the smaller fish when caught are put back to live and fight another day, they get the chance of growing big and heavy before they are very old. Quite recently pike of 23 pounds and 32 pounds have been taken in the Midlands.

Most waters, however, are too much fished and the smaller specimens are usually killed, so that few survive to the worth-while-being-stuffed stage.

Pike spawn in the spring, towards the end of February and in March, but under certain con-

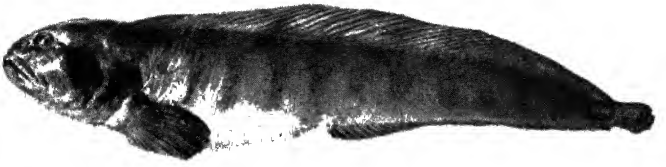
ditions the spawning may be delayed until April. They are essentially winter fish and in best condition during the winter months.

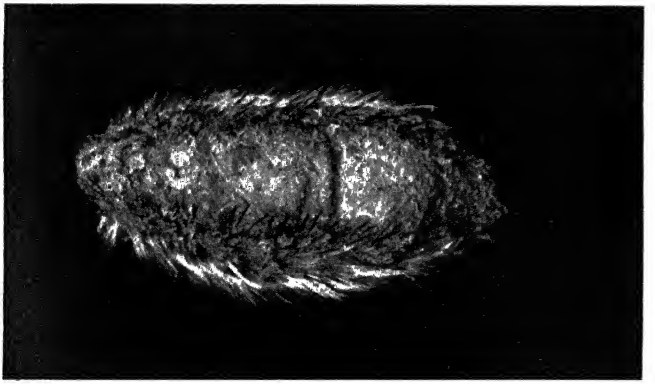
The young pike are striped with yellow bars which show up vividly against the deep green of the back and sides, but these yellow stripes match very closely the reeds and rushes in the water, and the fish, keeping for safety in reedy patches, are quite inconspicuous. This enables them to stalk their prey, resting almost motionless until the flash of a moving roach or dace reveals its presence, when a quick movement of the pike's powerful tail will bring it within snapping distance of its victim.

Gaining courage as they grow, the fish venture more often into clearer water, and the bars get broken up into yellow spots, seemingly in imitation of the stones on the bottom. Adult pike are generously spotted all over their back and sides, but for them no camouflage is necessary; they lord it over all the inhabitants of their neighbourhood and their sway is ruthless. It is no wonder that the killing of a pike is never mourned or regretted, especially in streams or lakes where there are trout and grayling. I have assisted in netting pike out of a trout stream, and on dissecting some of the victims found partly digested trout in their stomachs: normal food to the pike, but too costly from the fisherman's point of view.

Their teeth are numerous and very sharp, not rigid, but bending freely backwards to admit easy

PLATE III





THE DOG-FISH
THE CAT-FISH
THE SEA-MOUSE

passage to a seized object, returning quickly to the upright position again to prevent its escape. A scar on my left thumb bears witness to an incautious handling of a supposedly dead pike many years ago.

Skates and Dog-Fish (Plate III)

These are cartilaginous as distinguished from bony fishes, and are flattened from back to front instead of from side to side, as in the case of plaice and most " flat " fish.

The empty egg-cases of the skate, or ray, are familiar finds on the sea-shore, and are often called " mermaids' purses " on account of their shape and leathery nature. The eggs in their cases are laid in deep water and often buried in the sand with two of the tendrils, which extend from the corners of the rectangular case, sticking out into the water. Through these tendrils the supply of water is drawn in for breathing purposes. The eggs of the dog-fish are similar in shape, but the corner tendrils are much longer and wind around, or are wound around by the mother fish, sea-weed or rocky projections in order that they shall be secure during the long period of incubation, which is often from two to three months. If the eggs were not so secured they would be liable to destruction by being washed on the shore or against rocks by the waves.

In one of the marine laboratories a dog-fish was observed in the process of securing her egg to a

waste pipe running through the tank; she took the ends of the long tendrils in her mouth and swam round and round the pipe until the fastening was quite secure.

When the young fish emerge from the eggs they are well advanced in development, and have little of the egg-sac left, being able almost at once to begin food-hunting for themselves. Like nearly all the bottom feeders, they are white on the under-side but coloured on the back to match their surroundings and render them as inconspicuous as possible to their many enemies.

Photographed along with the dog-fish on Plate III is the cat-fish, which has a number of sensitive barbules or "whiskers" round the jaws; these barbules have a tactile function, and the fish can feel its food as well as see it. Cat-fish are commonly taken in the trawls and are good eating, though one might not like the dish so well if it were plainly described as cat-fish! In this respect both the cat-fish and the dog-fish suffer unmerited depreciation, for the flesh of both is nutritious as well as palatable.

Whether the cat-fish gets its name from the "whiskers," or from the noise like spitting which it is said to make when caught, I do not know; probably the hissing noise is caused by the rush of air and water through the gill covers.

The sea-mouse is not a fish, nor yet a mouse, but it resembles the latter, and so gets a place next the cat. The sea-mouse belongs to the more lowly

worm family, and lives in the mud at the bottom. The body is covered with short soft fur, and there are also longer and stiff bristles which, when clean, shine with colour and iridescence. It is a favourite food of the cod, which has one very efficient barbule, or tactile organ, under its lower jaw, and with which it searches for dainties such as the sea-mouse.

Perch and Other Prickly Fish (Plate IV)

The common fresh-water perch is a very handsome fish with boldly marked green bars and bright red fins, but it is not nearly so conspicuous in the water as out of it, for amongst the reeds and water-weeds where perch delight to hunt for food the colouring merges with the surroundings so well and the markings are blurred so that it is often difficult to follow the fish's movements.

My earliest recollections of live fish and birds connect the perch and the bullfinch. Near my home in Perthshire there was an old disused quarry hole, a rather dangerous place for youngsters, where there were plenty of small perch to be caught with carefully selected worms.

As there was no stream near and the quarry hole was isolated from any other water it puzzled me how the fish could originally have got there; probably the spawn had been carried by visiting ducks or other water-fowl. The perch lays a large number of small eggs attached to each other by a gummy

substance, and extending in long strings of tiny amber beadlets. These strings festoon on the roots of trees or bushes in the water and are much sought after by many water-birds.

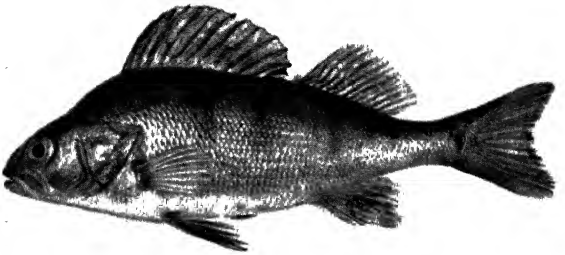
On these summer days we made the acquaintance of several pairs of bullfinches which nested in the bushes among the rocks on the side of the quarry, and we were much taken by their tuneful, but quite unprintable, " choo, choo " (I can whistle it now, but can't find a letter rendering—there was a " th " in the " choo " somewhere !) of the birds. We set ourselves assiduously to learn this double note, and when quite proficient announced it as our new call for special friends, feeling very proud of having hit on something so difficult to copy.

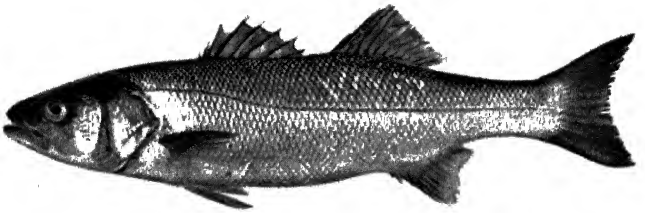
The skin of the perch feels rough to the finger, and the roughness under a magnifying glass is seen to be a multitude of minute needle-points sticking up at right angles to the scale.

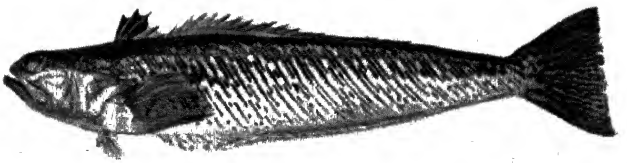
It is worth noting, at this first mention of scales, that only a small portion of each is exposed on the fish ; the remaining, and larger, portion of each scale being tucked away under others like tiles on a house roof.

The colouring matter in the skin reacts very quickly to nervous impulse, generally, but not always, conveyed through the eye. In moments of pleasure or content, when the worms have no barbed hooks in them, the colour globules expand and spread, star-wise or blob-like, so that the colour

PLATE IV







THE PERCH
THE BASS
THE GREATER WEEVER

*

is dense and brilliant (blushing with pleasure); under shock or fear the nerve impulse causes these cells to contract into their smallest space and the resulting effect is paleness.

The young perch congregate into shoals in the autumn of the first year and appear to become mature about the third year. They have occasionally been observed to descend to brackish water, but are normally fresh-water fish.

A near relative, the *bass* (*Labrax lupus*), is common on our southern shores, and occasionally ventures into the North Sea. The eggs have the usual pelagic character, but in brackish water they sink, and probably the bass, like the grey mullet, spawns in estuaries or in fresh water. The young grow rapidly and migrate out to sea for winter, returning shorewards in large numbers in the spring and entering bays, harbours and estuaries. The young are gregarious and can be encountered in large numbers at certain times and tides.

Feeding near the surface on any small fry that are available, these shoal bass can be caught readily on any small " fly " or lure that resembles their food. I have frequently amused myself by throwing in matches, cigarette ends, small pieces of white paper rolled up, and similar objects, and seeing the bass rush greedily at the bait and very promptly reject it.

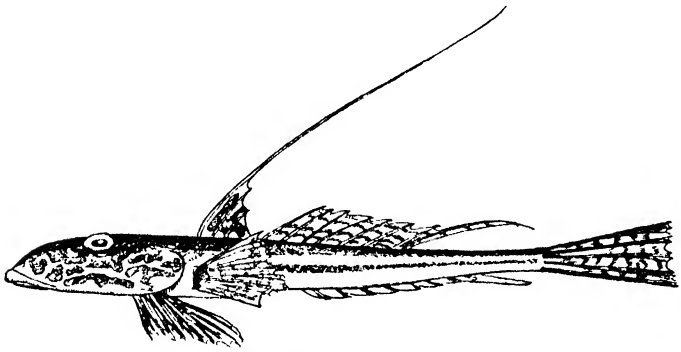
Later the bass prefer a diet of sand eels or prawns, and while still keeping in shoals they are much more wary and very easily frightened away into

deeper water. Like many other fishes, the older bass become independent and are only occasionally encountered close inshore. They must be tempted by something substantial and tasty, drawn to the feast by the smell of its preparation. I have seen it happen in Cornwall: a bucketful of pilchard scraps was buried at low tide in the sand, and as the tide rose the pungent oil oozed up through the sand and was carried out by receding waves. A cunningly baited half pilchard, secured to fine but strong tackle, was offered to the fish that had followed up the scent, and a fine 11-pound bass was the reward.

An unpleasantly prickly fish is the weever (Plate IV), whose dorsal fins are provided with poison glands in their front rays, and the smaller species, particularly, which is common inshore is known as the stinger or sting fish. Fishermen treat these little fish with respect, for they can use their poisoned spines with drastic effect and apparent intention. Effects of the sting vary with the individual, from a painful local swelling to a badly swollen whole arm or even worse. As the young fish as well as the adults frequently bury themselves in the sand they are at times a menace to bathers and may cause serious injury. A redeeming feature in the weevers is that when cooked their flesh is delicious, and when last on a trawler in the North Sea I noticed that instead of being thrown away with the offal the weevers were laid aside by the men for their own use. The steward showed me

how they were prepared, with great respect for the poisonous spines, and later in the day I enjoyed fillets of weever that were better than sole to my thinking.

Closely allied to the weevers is the dragonet, which, especially the male, is distinguished by the extra long front ray of the dorsal fin. The male



The Dragonet

is considerably larger than the female and much more brilliantly coloured, especially at breeding time. After his successful wooing, however, the colours fade, having apparently served their purpose! Among under-water personalities the male dragonet must be called a flirt; the female of the species is much less gaily adorned and much more modest in habit.

Grey Mullet: One of the Sea Aristocrats

Several species of grey mullet inhabit British waters, but the two most frequently seen are the thin-lipped (*Mugil capito*) and the thick-lipped (*Mugil chelo*). Both species are found all along the eastern shores of the Atlantic, though very seldom as far north as Norway; they are common in the Mediterranean and ascend the Nile and the fresh-water lakes of Tunis. Very few have been recorded in the North Sea net fishings, because the mullet is a coastal and estuarine fish, feeding on animal life which is only found in shallow water.

Very little appears to be known about the breeding habits of this fish, but it prefers quiet bays with fresh water running into them, and probably spawns in brackish or even fresh water. The eggs are said to be pelagic in structure, and while they would float in sea water, as nearly all sea-fishes' eggs do (those of the herring being a notable exception), they would sink to, or near to, the bottom in brackish or fresh water; this probably accounts for the absence of any record of mullet eggs being taken in the plankton nets.

Mullet have no front teeth, but the skin of the palate and tongue is covered with small tubercles and small teeth; the opening to the gullet is obstructed by thick fleshy swellings, which seem fitted for the rubbing of food in passing into the gullet; the stomach in its turn has a muscular structure

similar to the gizzard of birds. The mullet, therefore, has a very efficient system of mastication which alone would place it well up in the fishy social scale—much higher, say, than the vulgar codfish, which swallows crabs whole.

The principal food of the mullet consists of very small crustaceans, which it separates out of the mud, as well as small periwinkles and other univalves that are found on the eel grass and other marine plants. Just before the war an extensive experiment in the hatching and rearing of lobsters was carried out, and the fishery staff engaged on it had exceptional opportunities of observing the movements and habits of large numbers of grey mullet in the Beaulieu River in Hampshire. The mullet were frequently seen browsing on the colonies of hydroids which covered some of the old timbers, and possibly also obtaining the minute creatures living among the hydroids. When browsing on these growths the mullet swam completely on their sides, and as they were only a few inches below the surface their silvery sides brilliantly reflected the sunlight and faded away again into dark shadows as the fish resumed their normal position. My friend could not, however, induce any of the fish to take a bait, not even a newly hatched lobster, which is a dainty even for a fishy epicure.

The fry of the mullet are considered to be very destructive on oyster beds during the oyster " sick "

season, the free-swimming spat being ideal food for the little fish, who devour the minute creatures in great quantities. The young fry are gregarious and often swam up the creek in a large shoal in front of the dingy, passing from salt to fresh water in a few minutes without any apparent discomfort. On the hulk there was an oil engine used for driving the propellers of the rearing tanks, and the cooling water was discharged through a pipe just under the surface at considerably over blood heat; the fry used to crowd round this flow of hot water, jostling and pushing each other into a solid mass, and it was amusing to see them trying to keep in the warm zone. If disturbed, the fry would scatter, but would soon come upstream again to their hot bath, although there was often a current of anything up to six miles an hour.

Mullet have been credited with intelligence in addition to their good table manners, and instances are recorded where their actions seemed to indicate fidelity to their kind. If surrounded by a net, the fish will throw themselves over the head-ropes in order to escape, and in the Mediterranean this trait is so well known that the nets are provided with flaps, supported by bamboos, which float on the surface and prevent such escape. This is not, however, altogether a proof of intelligence, for small mullet will also attempt to jump over the net when they could more easily swim through any of the meshes. Day quotes an occurrence at Mevagissey,

where a shoal of mullet entered the harbour and were trapped in by nets: "The fish first tried to jump out, but a net was raised to bar that route. The water was very clear, and the fish were seen to swim round and round, to try to find an exit. Next they attempted to get under the foot-rope, and at last one made a push and became meshed. When this was done, another came and lay down beside it, and nothing could drive it away; in short, all escaped but these two." The grey mullet, like the bass, has a prickly dorsal fin, but in the former the fin has four spines, while in the latter it has eight; the two fish, though similar in appearance, need not therefore be confused.

The Plaice

Pride turns its Head. As an example of a typical sea (food) fish the plaice is interesting, especially as in early life it undergoes a curious metamorphosis —from a perfectly symmetrical, round fish, with an eye on each side of its head, to a flat fish with both eyes on one side.

In the case of the plaice, like practically all the important food fishes, there is no parental care of the young in any degree; the eggs being shed broadcast in the water and floating helplessly, at the mercy of wind and tide and enemy, during the period of incubation and infancy.

The plaice ranks high in importance from the economic standpoint, being only exceeded by the

haddock, cod, and herring, and persists in spite of intensive fishing on the grounds which it frequents.

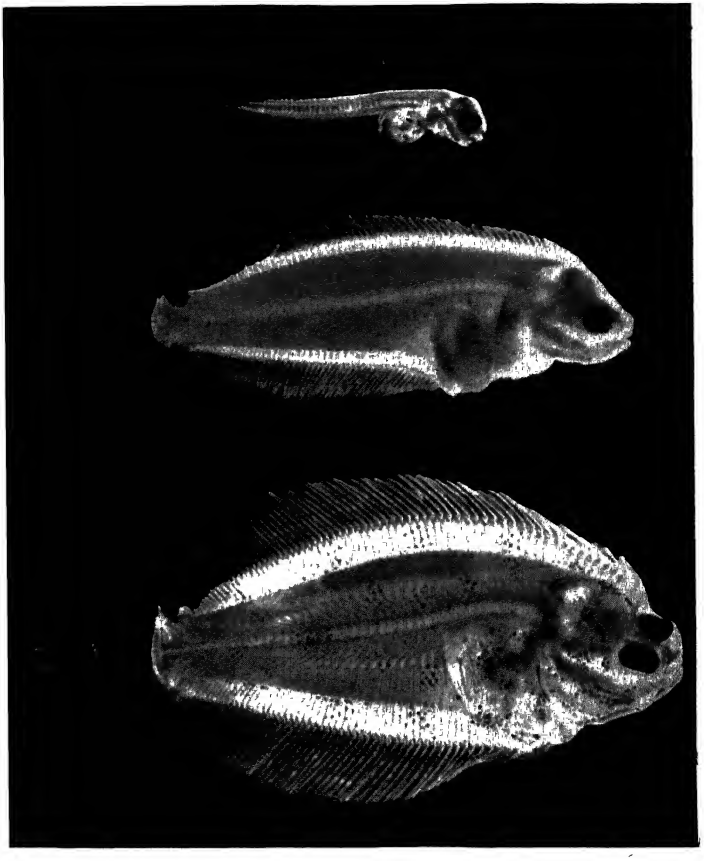
The plaice spawns in the winter months, and the main breeding grounds have been located by counting the number of eggs taken in the plankton nets at various stations. The eggs float in midwater and form part of the plankton or drifting animal and vegetable life which is the basis of the sea food supply. By using special nets for examining specified areas of water the number of eggs of the different fishes can be ascertained and compared, and in that way the main spawning areas can be defined.

This particular branch of research work is often very unpleasant, because both cod and plaice spawn in winter months, and manipulation of plankton nets and their catches then is a cold, wet job.

The eggs of the plaice float in midwater until hatched, and this period extends over from ten days to a fortnight according to temperature.

When the egg is burst open and the young fish emerges, it subsists on the yolk-sac at first until its mouth is open and functioning, when the fish commences to feed upon diatoms and minute crustaceans. By the time the yolk-sac is absorbed the young fish is able to secure its own food, and at this stage is of a normal shape and appearance, the eyes being opposite each other—one on each side of the head.

As the fish gets larger and deeper the left eye



THE EARLY GROWTH OF A PLAICE, CHANGING
FROM A ROUND TO A FLAT FISH

begins to move towards the top of the head, where it eventually arrives, and finishes up alongside the right eye.

Whilst this change is taking place the young fish has been altering its mode of swimming. First it swims upright, but as the left eye moves upwards the fish's body is tilted so that the eyes are always in a horizontal position.

By the time that the change is complete the young fish has taken up its position on the bottom, and is about ½ inch long. It is still transparent, and only the eyes and black pigments are visible, but the right (now upper) side quickly produces colouring matter to render it similar to its surroundings and less conspicuous than the milky white of the growing flesh.

Young plaice are much esteemed as food by other bottom feeders, and their ability to assimilate the general colouring of their surroundings is their chief means of escaping the attention of their enemies.

Viewed against a white background, the mottled browns and greys of a flat fish are quite conspicuous, but on sandy or muddy ground, when with a few undulating movements of body and tail they can partly cover themselves, the markings merge imperceptibly into the general effect.

Watching young flat fish on the sandy bottom of an aquarium tank, one can often first distinguish large stalk-eyes well above the sand, especially as

these eyes move in jerks, and it is surprising to see a small, round, black object on the sand suddenly rotate a quarter turn! A closer look will reveal the outline of the dorsal fins, and probably the pectoral fins, and by that time the whole fish may have revealed itself by one of its characteristic undulating movements.

It is not until about 4 or 5 inches long that the plaice gets its red spots, and unless these are merely for "swank," it is difficult to account for them. As we shall see in a later chapter, light fades away rapidly in the sea water, and adult plaice live normally at a depth beyond where the red rays can penetrate or emerge.

The blue-green of salt water is a most efficient filter of the warmer colours, and red is the first to go. A simple experiment with a piece of tinted glass and a magazine cover will demonstrate that, and one wonders what is the object of the plaice's red spots. Perhaps it is pride in the coming of these that turned its head! A perpetual effort to look round on to one's back would in time permanently affect the eyes!

There is a fish which is taken in quite deep water off the Norwegian and Icelandic coasts, known as the Norway haddock, which is bright scarlet, although living in a depth where all light is practically absent. One can only accept the scientist's suggestion that this bright colouring is just an outward manifestation of some inward change in

the fish, and is of no value to it. There is an analogy here with the scarlet creepers of autumn—the colouring matter being of no use to the plant.

The plaice is a bottom feeder, making its meals of animals that live on the sea floor, especially certain kinds of shell-fish. Its migrations in the early stages follow the prevailing southward drift of the southern North Sea towards the shallow nurseries in the sandy-bottomed regions of the coast of Holland.

Growing in size and strength, the fish become more independent, and while some remain within a comparatively restricted area, others roam far and wide in search of better pastures. This has been established by marking a great number of live fish and returning them to the sea, as will be described later.

Most of the flat fishes have the right side uppermost, but there are exceptions, such as the Topknot, which has turned the other way, and has its left side uppermost.

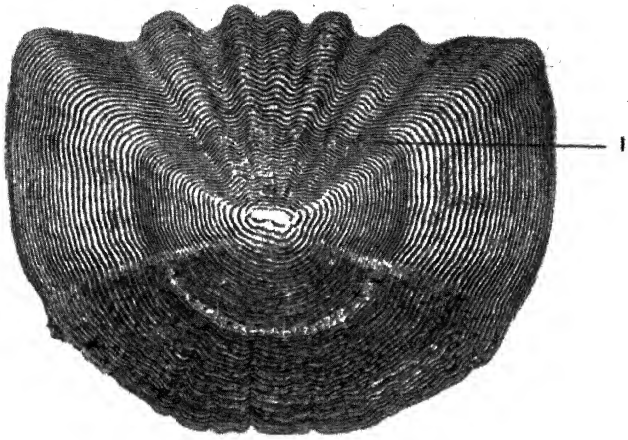
That curious fish, the John Dory, which appears on the cover of this book, seems continually to be inclined to join the flat fishes, for it swims with a decided "list," and never seems at all stable; the facial expression would lead one to think that it is annoyed at not being able to swim in a "sober" way, but although unfortunate in that respect the John Dory has had many legends written about it, especially about the black "finger-marks" on each

side of its head. One writer declares that the John Dory is the fish that St. Peter caught at Gennesaret and marked with his thumb as he recovered the tribute money, and there are other stories of a similar nature.

The John Dory can at least claim to be known by its eccentricities !

Birth Certificates

The scales of many fishes carry records of their age, as well as of their rate of growth, their good or bad feeding seasons, and even (as, for instance, in the case of the salmon) their migrations. The science of scale reading has made great strides during the last twenty years, and the understanding of the fishes' own records is of immense value to those concerned in fishery research. Not only our own marine laboratories, but those of other nations, employ scale examination in their efforts to increase their knowledge of the growth and movements of the more important food fishes. It is open, however, to anyone with simple apparatus and with very little trouble to find interest and profit in trying to elucidate the life history of a fish as written by the fish itself, and I will endeavour to show how it can be done quite simply. Scales vary a good deal in size and shape, but the growth is always from the centre outwards ; in some cases the scales are completely embedded in the skin or the flesh, while in many others only



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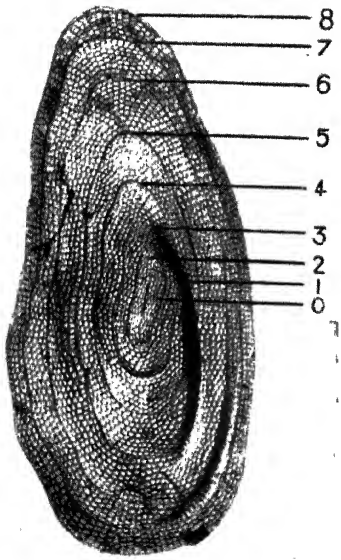


2

3

1. SCALE OF A YOUNG GRAYLING
Weight, 10½ ounces; length, 11½ inches, age one and a half years

2. SCALE OF AN EEL
Weight, 9 pounds; length, 40 inches (*See page 24*)

3. SCALE OF A SMALL TROUT SIX MONTHS OLD

a small portion is exposed, the remainder being hidden under others, like tiles on a house roof; the eel scale on Plate VI is in the first category, and the grayling in the second; the lower (darker) portion of the grayling specimen being that which is exposed, and it will be seen that the ring markings have been partially erased by the friction of the water.

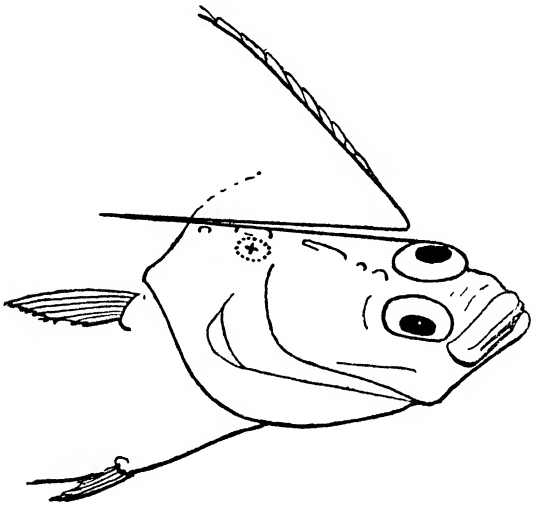
When the young fish has reached the "fry" stage, after the yolk-sac has been absorbed, the scales begin to appear as minute deposits in pockets in the skin, and very soon the whole body is covered with these embryo scales. As the fish grows the expanding flesh has to be protected, but instead of additional scales being produced each original one is enlarged by rings round the outside edge; these rings being the margins of extremely thin layers on the under-side of the scale, each such layer being a shade larger than the preceding one. The smallest figure on Plate VI shows the scale of a small trout just about six months old; the centre space is the original scale, and the concentric rings record the subsequent growth. During the summer months, or that period when feeding is best and most abundant, the general growth is correspondingly rapid, and the rings on the scale wider apart than in the winter, or period of food restriction, when the band of closer rings is formed, or there is a more or less complete cessation in the progress—*i.e.*, the winter check. Here is another

example of that wonderful rhythm of life that gives us night and day, summer and winter, a time to grow and a time to cease from growing, a time to feast and a time to fast, a time of plenty and a time of scarcity, a time to get and a time to lose. A close analogy to the fish's scale will be found in the concentric rings of a tree trunk, the quicker growth of the summer making a distinct contrast with the slower progress in winter. The marking on the eel scale differs a little in detail because the rings are not continuous, being made up of separate "tiles," but the winter checks are there quite plainly, and although this scale is only about $\frac{3}{16}$ inch long, it records eight years' river life, to which must be added the two to three years spent by the fish in its sea journey to our shores, because the eels do not begin to grow scales until they come into fresh water. This early sea life is recorded on the otolith or ear bones, and although in the elver these are very small and difficult to find, a skilful and persevering friend of mine succeeded in securing one which, when magnified, showed two and a half years' growth.

The life history of the salmon will be described in a later chapter, but I recommend the beginner to start with a salmon scale, because that fish has very marked changes in its career, and these show up clearly on its scale record. If possible, pick the scales from the shoulder of the fish with a pair of forceps, and if not wanted immediately put them in

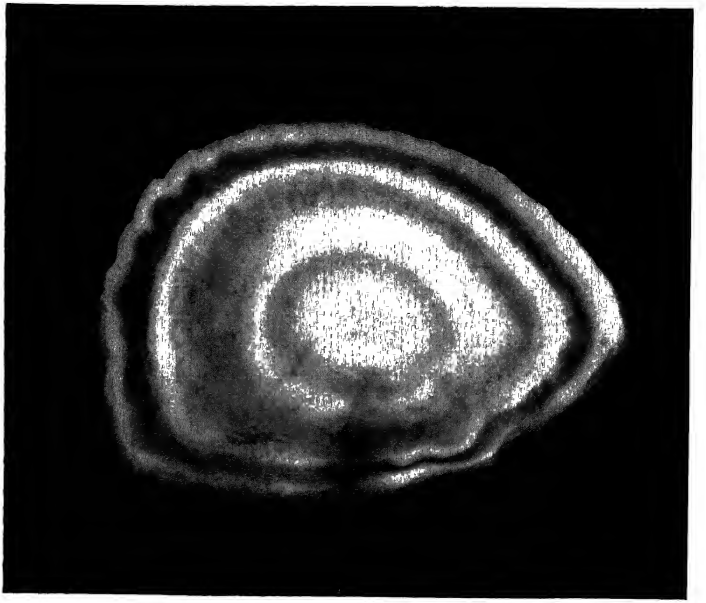
a folded piece of stout paper so that they may not curl up. Wash two or three in clean water, and if you can remove the thin film from the outside with a sharp knife so much the better, although this is not necessary to begin with; wipe with the corner of a handkerchief, and then rinse again to make sure that there is nothing adhering; place between two glass slips while still wet, and put aside with a small weight on top for a few hours to dry out. Bind with a piece of gummed paper, on which write particulars of the fish, its weight, length, sex, etc., and your specimen will keep indefinitely. When examining a specimen look first for the centre, and do not be surprised if you find that imperfect, because salmon are liable to lose a number of scales in the course of their journeyings, sometimes on stones or rocks and in the struggles on the spawning beds; such lost scales are replaced by new ones, but these cannot show the early growth, and the space left by the lost scale is filled in by new matter having no markings. The specimen on Plate IX will serve as a model, though only a small proportion of scales reveal a spawning mark, not many escaping all the dangers of a long sojourn in the river and survive to spawn a second time. In distinguishing the winter bands it often helps to look for them along the "shoulder" of the scale—*i.e.*, where the lines merge into the smooth portion at the bottom of the scale.

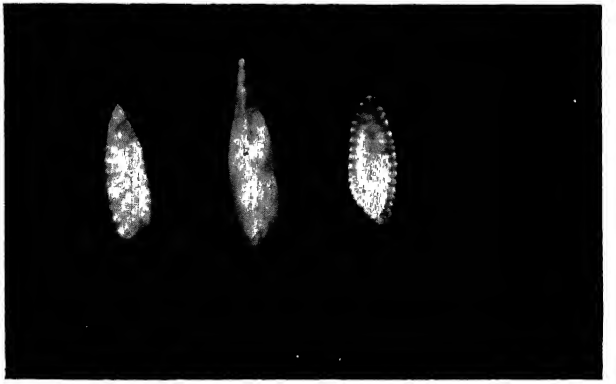
Otoliths. In some fish, notably the plaice, it is much easier to read the yearly growth on the otolith, or ear-bone, than on the scales, and the results are equally reliable. It is doubtful if fish "hear" at all in the ordinary sense of the term, and certainly they have no visible ears, but the otoliths probably



serve as dampers on the waves set up by disturbances from the outside, and so are of use in balancing and orienting the fish; they lie, one above the other, just behind the brain, and can be found in the following manner: Lay the fish on a board or table and make a cut right through the head with a strong and sharp knife, as shown on this drawing, just grazing the eye that is furthest from the mouth and the last tubercles on the gill cover. The exact

PLATE VII





THE OTOLITH OF A PLAICE
OTOLITHS OF HADDOCK, WHITING, AND COD

position of the otoliths is marked on the drawing by a dotted line enclosing a "X"; in a plaice of filleting size they will resemble lemon-pips in shape and appearance, but are brittle and easily broken. If an otolith is held up between finger and thumb to a strong light the alternate light and dark zones can be distinguished, and each pair marks a year's growth. As plaice spawn in the winter, the light centre is the first summer's feeding and the dark zone the first winter. The practical application of this knowledge regarding the plaice will be described in a later chapter.

Otoliths vary greatly in shape and size; those of the cod, for instance, being large, and those of the salmon very small in comparison. If you want to make sure that the fish which appears with its tail in its mouth when served on the dinner table (strictly speaking, the tail is through the eye) is really a whiting, examine the otolith; if that is about ¾ inch long and pointed you have got the right thing, but if the otolith is short and stubby, or if it has a fluted edge, you are having a substitute, though a harmless one.

The Eel

The story of the eel is nearly as far advanced as that of the salmon, and the discovery of the exact spot which could be called the eel's home would bring our knowledge of both fishes about level.

But up to the present, and in spite of a great deal

of careful and painstaking investigation, extending over many years, the home of the eels has not yet been located. It lies somewhere west of the Azores, perhaps even in the Sargasso Sea, possibly at a considerable depth, and quite certainly covers a considerable area.

The story as we know it begins with the Leptocephalus, as they are called—tiny leaf-shaped creatures of a few weeks old, coming up towards the surface of the sea to begin their marvellous journeying. They have been traced in different stages and in different regions, and appear to come on the track of the great Atlantic Drift. When a year old they are about $2\frac{1}{2}$ to 3 inches in length by $\frac{3}{4}$ inch in depth, but very thin and almost transparent, the only colour pigment being in the eyes. I have on my desk now some specimens of these oddly shaped little creatures, and when I think of their great 2,000-mile sea voyage I wonder at it all, and the thought comes that these southern seas must still be charged with the spirit that drove Columbus forward on his seemingly endless quest. You remember the poet's version:

"Behind him lay the gray Azores,
Behind the gates of Hercules;
Before him not the ghost of shores,
Before him only shoreless seas.
The good mate said, 'Now must we pray,
For lo! the very stars are gone,
Brave Admir'l, speak, what shall I say?'
'Why say, Sail on, sail on, and on!'"

And so our little elvers sail on, and on, until they reach our own seas. Here they seem to pause not only in their journey, but in their feeding, for the leaf-shape, which was perfect for their sea journey, is inconvenient for the rivers and streams which are their objective now. And so their shape changes and their bodies contract, colour pigment appears, and the beginning of the scale armour, and the hosts of elvers ascend our rivers as thin, round, slatey-coloured, little wriggling things, so numerous and so closely compacted as often to make the bottom of the water appear to be black. Many years ago now, when quite a wee laddie in a Scottish town, I used to join in the "eelie" season just as I did in the "top" or "marble" seasons as they came round. For four or six weeks in the spring one could have great fun in wading barefoot in the burn and scooping up the little eels (so numerous were they) in the hollow of one's hands. There were certain ceremonies to be performed, too; one took the form of reciting a doggerel verse to the captives, of which I only now recall two lines:

> "Eelie, eelie, tie a knot,
> And I'll let you in the water float."

Those who failed to wriggle sufficiently to justify this offer went into our pockets for later use in conjunction with the necks of other boys sitting in front of us at school (if, as has happened, we hadn't forgotten all about school!), or with tempting letter-boxes and such-like receptacles, though we

couldn't wait to see and hear the results should a nervous person happen to find these additions to his mail.

In some rivers, notably the Severn, the elver migration is so great that for a few weeks many men and women make a living by catching the elvers in curiously shaped nets made of willows and coarse canvas, filling pails and taking them up to the "farm," where the elvers are sorted, weighed in thousands, packed in shallow boxes with some ice, wrapped in cotton-wool, sealed up, and sent in all directions for turning out alive into ponds and lakes. Hundreds of such boxes go to Holland and other European countries every year from the Severn.

But all this time the elvers are wriggling their way up-stream, up apparently impossible falls and obstacles until they find a place to their liking. Here they settle down to develop and grow, eating voraciously and with little discrimination, often denuding the stream of other fish by devouring their spawn and young; here they stay until the call of maturity makes them prepare to return home. It is not age or growth or size, for some eels are found on their homeward journey when comparatively small and young, while others are much bigger and older. But when this compelling call of maturity comes it will not be denied, and the eels change colour, their eyes enlarge (sign of preparation for deep-sea swimming), and they turn back to the

sea. Down, down stream they go, sometimes even crossing from one piece of water to another over a wet meadow (I have seen them, and write of what I know), undeterred by anything short of sheer physical impossibility. Down to the larger rivers, out to the estuaries, past the harbours, away back those thousands of miles to their home. There the eels from all the seas and rivers assemble—from the Baltic and from the Mediterranean, from the Tay and from the Tiber, from the St. Lawrence and from the Nile—there they meet, there they mate, and there they die, *for they never come back*; and from there will emerge again another great host to continue the unending cycle. How *can* these things be?

CHAPTER II

THE SALMON: KING OF GAME FISHES

Of all the finny inhabitants of our waters the salmon is probably the most highly esteemed. In symmetry of form, in the brilliance of its silvery armour, in dash and grace of movement, and, above all, in the supreme excellence of its richly tinted flesh, the salmon has no peer.

The amazing story of its migrations, its indomitable perseverance in overcoming obstacles to its progress, its high economic value, and its fine sporting qualities, all combine in the salmon's claim to royal status among fishes.

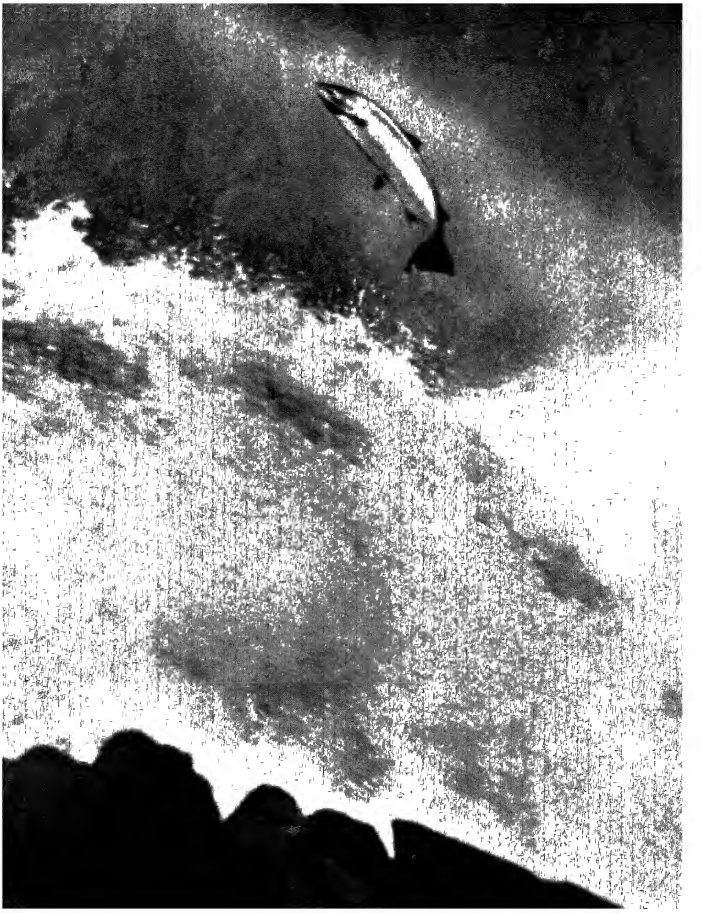
From the point of view of food production for man the salmon has few rivals. The young fish migrate to sea when only a few inches in length; they find food in the sea in such abundance that after one year's sojourn the smolt of 2 or 3 ounces will have become the grilse of as many pounds; whilst after two or three years in the sea the smolts will have reached maturity and may weigh up to 40 pounds or even more. The feeding of the young salmon in the sea costs us nothing, the rivers provide free transport, and all that man need do to ensure such a rich return is to conserve our priceless rivers and water-ways and to keep

them sufficiently clean and pure, so that fish may ascend them to the breeding grounds, and so that the young fish may get back to the great feeding realms of the sea.

Unfortunately, however, in this industrial age many of our beautiful rivers and streams have become nothing more or less than open sewers in which no fish can live. Some of this deadly pollution is, no doubt, unavoidable, but much of it could, and should, be prevented. We do not allow citizens promiscuously to dump refuse in the street (where, after all, it can be dealt with without spreading the nuisance far), but a running stream seems often to be considered a natural receptacle for any kind of filth, and such an outlet for refuse spreads pollution far and wide.

Many rivers are seriously overnetted, so that the potential breeding stock is depleted, immediate gain having a stronger claim than prospective prosperity. Salmon ascend the river to propagate their species, and dead fish cannot do that.

In many districts poaching is still rife, especially in the winter on the spawning beds; and what insensate folly it is to take fish then! After evading all the obstacles of coastal and river netting, overcoming weirs and waterfalls, battling against floods and impure water, the fish, having reached their objective, are almost certain reproducers of their species, while their food value then is at its very lowest.



A HIGH JUMP BY A SCOTTISH ATHLETE

Is it any wonder, then, that fresh salmon is dear to buy? And even at "fresh salmon" prices it is economically as cheap as cod-fish, because the nutritive value of salmon flesh is far higher than that of cod, and the amount of offal or waste much lower.

But even with all these handicaps our country produces annually more native salmon than all the European countries put together; and with proper attention and conservation the present yield can be greatly increased. One has only to consider the record for the last twenty years or so of such rivers as the Herefordshire Wye to realise the enormous value, not only to anglers, but to the whole community, of the wise policy pursued in such cases.

It is scarcely to be hoped for that salmon will ever again be able to ascend the Thames and other great rivers running through large industrial areas, unless some wonderful means can be devised for assisting the fish over or under the barrier of poisoned water inseparable from proximity to great cities, but it is not too much to hope that the insidious growth of pollution in other rivers may be checked before it is too late, else there will soon be many districts where the only salmon to be seen will be those that come from happier lands, where "they eat what they can and 'can' what they can't!"

The habitat of the Atlantic salmon lies along the northern edge of the Atlantic Drift. In one bay on the eastern coast of America salmon are still found: they are common in Canadian bays and

rivers, and as far north as Labrador; occasionally they are found in Greenland waters, and the rivers of Iceland hold them. There are no salmon in the Mediterranean, but they frequent the coast of Portugal, Spain, France, Denmark, and Holland; they enter the Baltic, and all along the coast of Norway as far as the frozen seas of the far North.

Our homeland is most fortunately situated, having rivers running into the sea in all directions, to tempt the salmon to ascend and breed in them.

Our coast-lines, measured without reference to small details, are equal in their aggregate length to the combined coast-lines of France, Belgium, Holland, Denmark, and Germany, and in the number and suitability for salmon of rivers running into the sea our islands are unequalled.

We know very little of where the fish go in the sea, but obviously they must have crossed the Atlantic at some time, and, occasionally, marked fish are caught which have made considerable journeys.

Many books have been written about salmon, and there is still much controversy upon vital points in the fish's life history; but a great deal has been decided definitely by scientific research, and the following brief sketch is based upon the results of exact investigation.

A great step forward in our knowledge of the subject was possible when, about twenty years ago, a patient and painstaking Scottish investigator published the results of his labours in a letter to the

Field, setting out how he was able to read the main facts of the salmon's history on its scales.

Curiously enough, the inventor of the microscope many generations earlier had used the scale of a carp in some of his experiments, and made a shrewd guess at the connection between the rings marked on the scale and the fish's age ; but he did not pursue the matter further, and it seems to have been forgotten until the publication of Mr. Johnston's letter in the *Field*. Since then many able investigators, notable amongst them Mr. J. A. Hutton (to whom I am indebted for the fine photographs illustrating this paper), have proved the accuracy of Mr. Johnston's deductions, and in doing so settled some long-standing controversies.

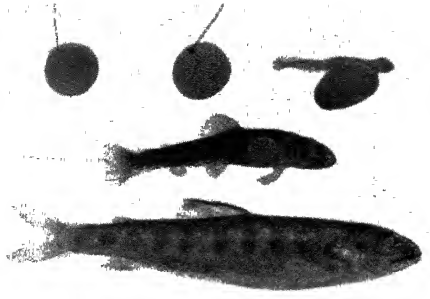
The salmon's life is spent partly in the sea and partly in the river : the two chief adventures are first a feeding migration from river to sea as smolts, and then a spawning migration from sea to river as adult salmon.

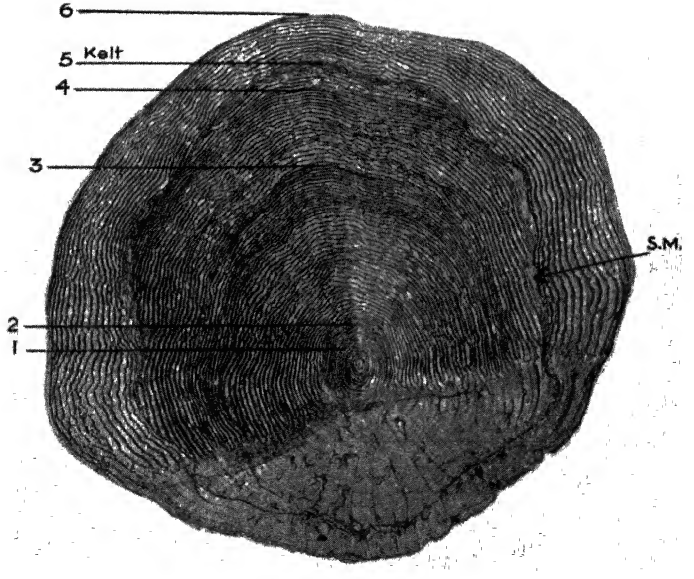
Salmon return from the sea to fresh water for the purpose of propagating their species, because the spawn cannot live in salt water. This journey is usually a homeward one in a very real sense, for it has been proved that in a large percentage of cases the fish return to the river in which they spent their early days. This desire to return to their original haunts at breeding time is a general tendency in animals, and familiar examples will readily come to mind. An unusual one was brought to my

notice by a Scottish farmer, who gave me instances of sheep leaving their flocks and wandering back many miles to the hillside where they spent their early life, even skirting towns on the way. Marked swallows have been traced returning to the nests in which they were hatched the previous year, and the homing instincts of domestic animals are well known to most of us ; but none of these examples lessen the mystery of the salmon's return after a sojourn in the sea, where there are no landmarks. How they do this is beyond our knowledge, and we must credit the fish with a sense or senses of which we know little or nothing. Where the salmon go in the sea is likewise unknown, for there are very few instances of their being taken in the trawl nets. It may be that salmon, being fast swimmers, can escape from the slow-moving trawl, but it is more probable that they are not bottom feeders, and that their movements are largely influenced by their food supply, which consists mainly of herrings, prawns, shrimps, etc.

This homing habit of the salmon has been proved beyond doubt by marking the smolts before they descended to the sea, sometimes by a small piece of fine silver wire secured in the back fin, and sometimes by cutting one of the fins or removing it altogether. In succeeding years the adult fish were taken in substantial numbers in the same river, with the marks still there to prove their origin. Of course, there are wanderers who occasionally make

PLATE IX





1. OVA. 2. EYED OVA. 3 ALEVIN
4 FRY. 5. PARR
6. SCALE OF A LARGE SPRING SALMON (*See page* 60)

long journeys (a sea-trout marked in the Tweed was recently recaptured in Danish waters in the Baltic), but it is certain that the majority of returning fish were bred in the rivers to which they come back to carry on the most fundamental thing in life —the propagation of their species.

On leaving the deeper waters of the sea, salmon appear to move along the shallow coastal area for some time before entering the river, either in search of their own rivers or to accustom themselves gradually to the change from salt to fresh water. In these shallower waters the salmon appear to cease hunting for food, and their existence from then on to the time of their return to the sea after spawning is solely dependent for nourishment on the oil and fat, etc., stored in their own bodies.

Some anglers will not agree with me in this, and will give instances in their own experience of salmon taking flies, prawns, worms, etc., evidently for food. Here, however, it will be well to keep to general principles, for although salmon will take a tempting morsel of food when such is offered, they follow a rule very common amongst fishes—*i.e.*, that of abstaining from *solid* food during spawning time. When I first fished for salmon I had access to a pool where it was possible, sometimes, to get an autumn fish on a frosty morning (if you got up early enough to forestall the other fellow) with a big bunch of worms. I used to be very puzzled by the chewed-up condition of the worms when I retrieved them

after fishing the pool right out. I believe now that the fish had chewed the worms to secure the juices without swallowing the solid matter. In this connection I might instance the plaice, in which the ova sometimes grows to a weight equal to that of the whole fish, and a bulk which quite precludes the swallowing of small molluscs, etc., which form the normal food of the species. If a plaice were to continue normal feeding during spawning time, irreparable injury to the fish would result.

In the case of the salmon there are also certain physical changes which are now accepted as conclusive that these fish cease to feed normally in fresh water. It is also obvious that their normal food is not available in sufficient quantity in the rivers.

The up-stream journey is hazardous, for if the nets have been safely evaded there are still the anglers, the otters, weirs, traps, and waterfalls to be surmounted before the ideal spawning ground is reached.

The leaping abilities of salmon are well known; indeed, the very name of the fish means leaper, and there can be few more beautiful animal actions to be seen anywhere than that of a salmon surmounting a fall. It is no mean feat for a heavy animal to project itself three or four times its own length into the air, but the salmon does it time after time until, having judged the position accurately, it manages to get over the top, and so on to its destination.

Having at last found suitable conditions—running water not too deep and a gravelly bottom—the fish drop back to the nearest pool where they can rest and conserve their energies for the actual spawning operations.

Sometimes this period of waiting may be prolonged, for although spawning generally takes place in late autumn, the fish may have entered the river quite early in the spring. In such cases they are very different in appearance from what they were at the beginning of their journey, the silvery hue having given place to a reddish or chocolate colour, and a general deterioration having become manifest. The male fish frequently develop an extension of the lower jaw into a kind of blunt hook, sometimes so long that it pushes up the skin on top of the upper jaw from the inside. The purpose of this hook is obscure, and it would seem to be just a manifestation of the physical changes taking place in the fish itself. Sometimes in the course of the fighting in which the males indulge on the spawning beds one fish will seize another by the tail and try to drown it by dragging it upstream: the hook on the lower jaw is useful in such an exploit, as it adds greatly to the grip, like the thumb on one's hand. The long stay in fresh water and abstinence from food naturally lead to loss of weight and to general lowering of tone: even the teeth do not escape, but become slack and are frequently lost.

Anyone who has fished for salmon in the early spring knows the annoyance of finding his flies damaged and torn by the teeth of mending kelts (as the spent fish are called), and it is probable that part of the recuperating process which the fish goes through before descending to the sea is the reproduction of a new set of teeth.

When ready to commence spawning operations the fish move forward to the place selected, the female in front, with one or more males in attendance: she has the hard work to do; they spend much of their time and energy in fighting each other. With strong, undulating movements of her body and tail, while lying on her side, the fish scoops out a hollow trench in the gravel, and then, rising to the surface, she extrudes a quantity of eggs, which fall into the trench through a zone of water charged with the fertilising element. The process is repeated at intervals extending over some days or even weeks, until the whole of the ova has been shed. The number of eggs so produced is about 800 per pound of the fish's weight, so that a 20-pound salmon will lay about 16,000 eggs, though, as will be seen, only a very small percentage come to maturity. Even while the eggs are being deposited there will be hungry trout and eels lurking around to make a meal of them, and gulls and terns will snap up large numbers. Those that are duly fertilised and covered amongst the gravel are liable to be disturbed and washed away by a new pair of

spawning fish which may have chosen the same spot soon after the first pair have left. Heavy floods may destroy the whole bed, or the reverse may happen and the river shrink so much that the beds are exposed to the destroying effects of drought or frost. Small cause for wonder that probably not more than 5 per cent. of the eggs laid ever hatch out.

The adult fish, kelts, are now exhausted and emaciated, with scarcely enough strength or energy left to set about finding their way back to the sea again: many of them, especially the males, die soon after spawning, and a number are so weak that they fall easy victims to the attacks of eels and other predatory water animals. Return to the sea is slow, and not infrequently the mending fish will remain in the estuaries, sometimes running up the river a little way, and sometimes going down to the sea temporarily, apparently not content to take the plunge into a marine life again until quite fit for it. Once back to the happy hunting grounds of the sea, the fish quickly put on flesh again and to a large extent recover their first fine condition.

The eggs at first are about $\frac{1}{8}$ inch in diameter, round, and of a reddish hue, due to the presence of oily matter of a pink tint scattered through the ball of yolk. After fertilisation the eggs rapidly toughen and will withstand considerable pressure, as the skin becomes strong and resistant; experiments have shown that a weight of 5 pounds may be placed on a salmon's egg before it is crushed.

The next sign of development is the appearance of round black spots showing through the translucent skin; these are the eyes of the embryos, and at this stage they are known as eyed ova. In many fish the eyes develop very quickly, and that would seem to be a kind of compensation for the absence of parental care. The first necessity of a newly hatched salmon is security, and its first conscious movement a wriggling into a dark corner between the stones.

Early in spring—the dates vary according to general conditions of water and temperature—the embryo salmon are ready to burst their thin shells, and emerge as tiny, feeble, almost transparent creatures, scarcely recognisable as fish at all; their movements are clumsy on account of the yolk-sac, which remains attached to them and contains the food necessary for their subsistence until they are strong enough to use their mouths and hunt for food. As the little alevins become stronger they gain freedom of movement, and with the complete absorption of the clumsy yolk-sac they gain symmetry and become very quick in darting about here and there in search of minute atoms of food. Between the hatching time and this "fry" stage the young fish lead a very secluded existence, being under no necessity to leave their hiding places, seeing that food is already provided; and probably this period is one of the safest in their whole life, though doubtless a few venturesome ones get

snapped up when they emerge from their shelter of the stones.

During the "fry" stage, which lasts about nine months, the little fish get their scales and those bright red spots between dark bars which later distinguish them as "parr" from young trout. In the parr stage their appetite increases rapidly, and they can be seen searching the shallows for any food that may be available. This is the time when their enemies take heavy toll, and only their great agility saves the young fish from extermination: eels pick them out from under rocks, trout chase them, young pike are very fond of them, whilst gulls, herons and cormorants are always on the look-out for such dainty morsels.

When about a year old some of the parr begin to prepare for their migration to the sea, and assume a silvery coating over the scales, a kind of silver-plated armour for the great adventure. It is difficult to assign a reason for this change and extra covering, unless it be protective colouring for their new environment. It has been suggested that the silver plating may be a safeguard against the pressure of the water in the open sea, but there is no evidence that salmon go into very deep water, and there does not appear to be any scientific basis for thinking that the thin silver coating on the scales can neutralise such pressure. Silvery fish are, however, less conspicuous in the water than coloured ones, for so long as they are swimming in

a normal position their silvery sides will merely reflect the surroundings and the fish will show as dark, shadowy forms only; when they turn or twist so as to catch the upper light then, of course, the silver will reflect the light and cause a revealing flash. I am inclined to think that the silvery condition is a sign that salmon do not live in very deep water, for all the pelagic sea fish are silvery (the herring, mackerel, tunny, bass, mullet, etc.), whereas the demersal fish are black or very dark (the cod, haddock, halibut, plaice, sole, etc.).

The migrating young salmon are called smolts, and on their seaward journey collect into shoals as if for protection, and they certainly need that. Many are killed falling down weirs and waterfalls, many get destroyed in insufficiently screened mill-streams and turbines, many more are destroyed by pollution of the waters through which they must pass, and all the while there are the fish-eating birds that follow the shoals, gorging on the smolts all the while. Even at the estuaries there are mergansers and goosanders waiting on the sandy spits for a meal of young salmon, which is much to be preferred to the flounders, which can now be despised. The destruction of young smolts in these ways is much greater than would appear at first thought; mergansers have been taken, for instance, with the remains of as many as forty recently eaten smolts in their stomachs.

The age at which the smolts migrate varies in different districts and under differing conditions of temperature, etc. In English rivers the largest number descend to the sea when about two years old, but a number will have gone in their first year, and some will remain until they are three years old, some even longer. Apart from variations in the rate of development of the fish there would appear to be a kind of insurance scheme in the spread-over: an insurance against the possibility of the destruction of the whole of one year's hatching if they all migrate in the same season and were overtaken by disaster, as sometimes does happen. The stay-at-homes may even have a place in this insurance scheme, because a fully-developed smolt is capable of fertilising the eggs of an adult salmon, and might be required for that purpose.

The late William McNicol, who knew more about salmon than any other man of his generation, told me that in some experiments he found that the three- and four-year-old smolts were almost all male fish with fully developed milt. If that were general it might account for the greater proportion of dead male kelts—they would be the older fish.

Once safely in the sea the smolts grow rapidly, for the food supply is abundant and inexhaustible: first, to suit young fish, there is what has aptly been termed the sea-soup, but more correctly the plankton of the sea, consisting of both animal and

vegetable matter in great variety; all the helpless drifting young of fishes, crustaceans, molluscs, etc., are plankton as well as the vegetable cells which form the basis of the whole colossal food supply of the sea. As the smolts grow they take more solid food—the fry of the herring and other sea fish, the smaller crustaceans, etc.—and in the adult stage the salmon's chief food is mostly herrings and shrimps, prawns, and young fish of all kinds.

The chief enemies of the salmon in the sea are seals and sharks, the latter in the open sea and the former near the mouths of the rivers. The chain of life in the sea takes many forms, and in one of these you get the shark eating the salmon, the salmon eating the herring, the herring the copepod, and the copepod the diatom.

So rich is this diet of the salmon that after one summer's feeding the "grilse"—as it is now called—is ready to return to spawn in the river, and the subsequent rate of growth is equally remarkable. The next "run" of fish is the small spring fish that have spent two summers and two winters in the sea, returning to the rivers early in the third spring.

Then follow the larger fish, those that have spent three or four years in the sea, and are now anything from 20 to 50 pounds in weight.

The return migration is also spread over a number of seasons, just as the smolt migration was, and so it will be seen that the spawning of fish in any one year will affect the supply of that river for the next

eight or nine years. Equally, the destruction of fish on the spawning beds, either by poachers or by those stupid people who cannot bear to see a live wild animal without wanting to kill it, will adversely affect the supply in the whole river for a like period.

To make this quite clear, let me cite the case of a salmon spawning in the autumn of this year: the ova will hatch out in the spring of next year (1932) and some of the smolts will migrate to the sea in 1933, some in 1934, and some in 1935. The adult fish will begin to return as grilse in 1934, and salmon in the three or four years succeeding that, while the later smolts will still be supplying full-grown salmon for the river in 1939 or even later.

And so the cycle of the salmon's life history is completed with the return to the river of the adult fish, and we have come back to our starting point in this study of it. And now, if you will turn to the illustrations on Plate IX, you will see how the fish has written his own history on his scales.

The upper illustrations show the first two years of the young salmon's life; the top row are the ova, the eyed ova, and the alevin with his "feeding bottle" attached. The middle figure is the fry when about six months old, and it is at this stage that they get their scales: first a minute deposit of scale matter in a pocket in the skin, and this initial scale grows in ratio with the growth of the fish in order to cover the expanding flesh. The lower figure of this group is a parr in its second

year and before it has assumed the sea-going silvery armour.

The lower illustration is a scale from a large spring salmon, and the fish's whole history is written thereon.

At the bottom of the scale is a portion from which the ring markings have been erased; this is the exposed portion, and the friction of the water removes the slightly raised markings which are the outer edge of the successive layers added to the under-side of the scale as it grows. The remainder, and by far the larger part, of the scale is hidden under others on the fish, somewhat like tiles on a house roof.

A little below the inner end of the line marked 1 will be seen the initial scale deposit, and from that to the line represents the first season in fresh water, the closer grouping of the rings near the end of this period being the winter check in the growth alike of fish and scale. Between the inner end of line 1 and line 2 is the second year's river life, first the wider rings of spring and summer feeding, and then the second winter check. At this age the smolt went down to the sea, and the greatly accelerated rate of growth can be seen in the space between lines 2 and 3, the abundant feeding in summer being followed by the scarcer period of winter. Another summer feeding in the sea follows, and at the end of that period (4) the fish returned to the river to spawn.

From 4 to 5 there is the period spent in the river, and the erosion of the scale during that period is very marked; the general deterioration of the fish during that period, culminating in the kelt stage, is reflected plainly on the scales, which would also appear to be drawn upon for the means of subsistence during the lean time. This fish had survived the kelt stage and returned safely to sea, where it quickly recovered strength and put on flesh again, as evidenced by the rapid growth of the scale beyond the spawning mark (s.m.); but the scar has not completely healed, and remains as evidence for us of the fish's movements. At the end of another summer's feeding in the sea the fish again ascended the river to spawn a second time, but was on this occasion captured by a lucky angler.

A certain number of salmon succeed in spawning twice, and their scales show the second spawning mark, and there are occasionally fish which somehow manage to escape all the perils of three successive sojourns in fresh water, but these are rare exceptions. On the other hand, many of the large spring fish have spent three or even four years in the sea without leaving it for the spawning beds—selfish bachelors who prefer the fleshpots of the sea to the hazards of domestic life in the river.

Certain parasites which attach themselves to the fish, both in fresh and in salt water, are also evidence of the fish's movements, and serve to check the

reading of the scales, which is now accepted as perfectly reliable; but there are still considerable gaps in our knowledge of this fine fish, and much need for constant study and research. The question of salmon diseases is calling for close attention; in spite of much careful research, the present conditions of some rivers are causing alarm on account of the baffling mystery of the trouble. It is to be hoped that this splendid national asset will be adequately conserved, not only for the angler (who, after all, gets only a small proportion of the fish that are taken each year, the nets—*i.e.*, the community—getting ten for every one the angler gets), but for all of us.

CHAPTER III

THE HARVEST OF THE SEA: FROM COD TO COCKLES

THERE is a fundamental difference between the harvest of the land and the harvest of the sea. When we think of the former there are always two aspects of it in our minds, the sowing and the reaping; our harvest hymns connect these two—"The sower went forth sowing." But in the sea there is no sowing, at least not yet, for we do not know how to replenish the store of fish from which we take such quantities; man has no control at all over the material of this industry.

The fisherman may be considered as the last representative, on any substantial scale, of the hunter, and he must go where his quarry congregates and is available.

Nevertheless, fishing is one of the four great primary industries of the world—the raising of crops, the raising of stock, the winning of minerals, and the winning of fish.

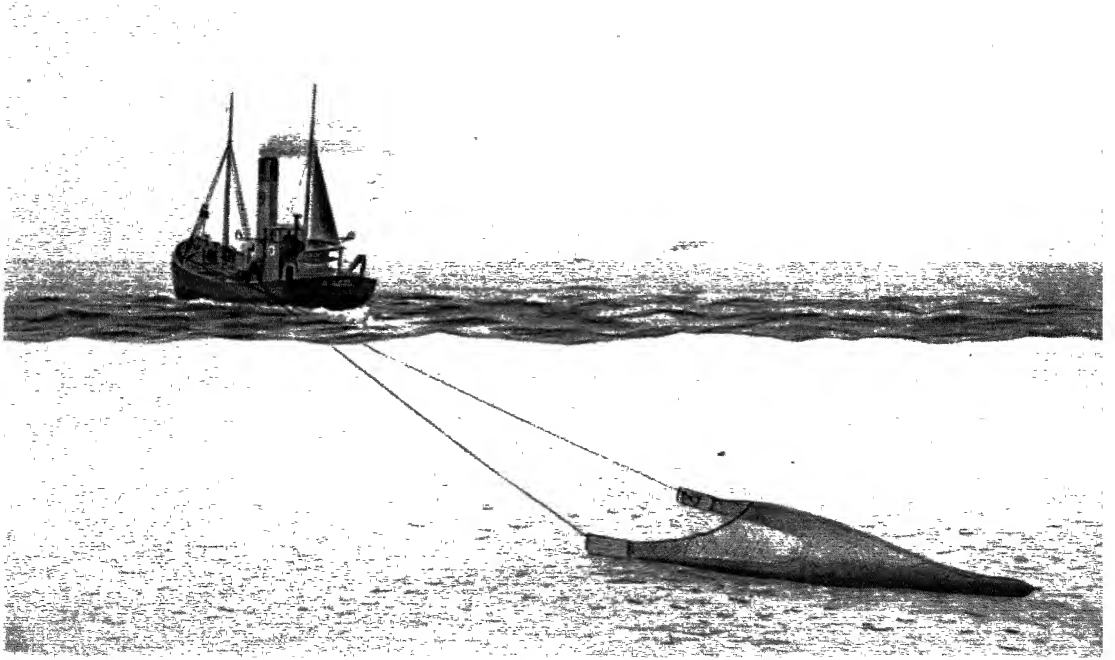
In this great industry our country has no equal, scarcely a close rival. Great Britain is the home of the greatest sea-fishing industry that the world has ever seen, and her fishermen are the best of their kind that ever shot or hauled a net.

The British Isles are situated in some of the most prolific seas of the world, and are surrounded by comparatively shallow water, which can be profitably fished. The earth has its deserts and the sea its deeps, and neither yield food for man. The parts of the sea which yield the harvest are mostly under 200 fathoms in depth, and chiefly under 100 fathoms. Most of the North Sea, therefore, is trawlable, and other shallow areas of the Northern Atlantic are within practicable reach—the Iceland banks, the Newfoundland banks, and even the sub-arctic seas.

These shallower portions of the ocean attract fish to spawning grounds and to nurseries, as well as to the abundance of vegetable food upon which all animal life in the sea ultimately depends. Not growing vegetation, for that is confined to very shallow areas where sunlight can penetrate, but the minute forms of vegetable life which are the first links in the chain of the sea's food supply.

Other things being equal, marine life is more abundant near the shore, and especially near the mouths of large rivers which bring down into the sea nitrogenous matter necessary to the growth of the vegetable plankton. (This will be dealt with further in a later chapter.)

But it is not every country bordering on the sea which has developed a fishing industry extending beyond its close inshore waters. The fishing population is a distinct section of the community, stand-



A STEAM TRAWLER AT WORK

PLATE X

ing apart from the general life of the country, more especially that section of fishermen engaged in deep-sea work. Even in our small islands examples of this will be found; most of those engaged in the trawler industry based on Milford Haven come from Yorkshire or East Anglia; the East Anglian herring harvest is gathered largely by Scottish fishermen; the people of the Orkneys are concerned mostly with agriculture, those of the Hebrides with fishing, and so on.

In Great Britain about 50,000 men are permanently engaged in catching fish, and an additional 15,000 occasionally so engaged.

Apart from the economic aspect of the subject, recent history has shown the advantage to the country of a flourishing fishing industry. In times of peace the fishing population forms the basis of the mercantile marine, and keeps alive that sea-sense so important to a maritime people. In times of war the fishermen are ready immediately to render invaluable assistance.

At the outbreak of the Great War trawlers were at once available for mine-sweeping, and ultimately over 3,000 trawlers and drifters were employed, whilst 58,000 fishermen were enlisted in the services.

The exploitation of the fishing grounds by the people of the country is therefore of great importance to the country, in addition to the increase in the food supplies which results from their efforts.

Of the commercial value of these food supplies

it will suffice here to say that the total quantity of wet fish landed in England and Wales during the year 1929 was over 14,280,000 cwts., and the value £14,444,000. This was an increase of 6 per cent. in quantity and of 10 per cent. in value over the previous year.

The writer's main purpose is not, however, to deal with the economic aspect of the subject, but to describe some of the methods by which the fish are caught, and to throw a little light on the lives of some of the fishes which are little known to us except where they appear cooked on the table.

An Irish chairman introduced me to a Dublin audience on one occasion by telling them that he only knew two things about fish—one, that it was very nice to eat when properly cooked, and the other (according to his wife) that it was very dear to buy.

That is, perhaps, chairman's license to some extent, but few of us have opportunities of watching the fishermen at work or of learning much about the habits or character of the fish, and so I am venturing to give very simple descriptions of different types of fishing gear and some details of some of the harvesting operations.

My interest in the sea and its inhabitants began very early, when, as a small boy, I used to spend the summer holidays at a small Scottish seaport. The harbour was a never-failing source of interest, for there were fish to be caught with hook and line,

an occasional short trip in a harbour tug, and always at intervals the setting out and returning of the fishing boats.

In those days there were practically no motor or steam fishing vessels—at any rate, in the smaller ports—and all the fishing was done from sailing boats. Some of the scenes are indelibly engraved on my mind, and one oft-repeated operation—that of the herring fleet setting out to sea, their brown sails glowing in the warm evening light, the white wake of the boats gleaming as they scudded out into the open—is a never-failing source of delight in retrospect.

On a fine night such a voyage is not unpleasant; with a favourable wind the fishing ground could be quickly reached and the nets shot before darkness came on, the waiting hours passed in various ways until morning came and the nets were hauled again. But there were many occasions when with the dawn the wind arose and the little boats were buffeted, while their gear was often badly damaged or altogether lost.

Back again in harbour there was the landing of the fish, sorting and cleaning the nets and the boats, and a great deal of work to be got through before needed rest could be taken.

The stay-at-homes had also much to do; damaged nets and gear required repairing, and I have watched and wondered for hours at the skill of the older men and women in the art of net-mending.

I can make netting of various types, but have never acquired the knack of mending, and in the case of herring nets accurate mending is essential. A botched darn on one's sock can be endured, and is not seen by others, but a botched darn in a herring net is fatal, because every mesh must be correct in size or else it is useless for catching fish. If the mesh is too large the herring can get completely through ; if too small the fish's head will not penetrate far enough for the cord to catch it behind the gills.

In the case of the longshore boats, fishing with lines and hooks, there is much to be done in preparation for the next day's fishing. Lines must be sorted out, the hooks cleaned and rebaited (mussels and other bait must, of course, be procured and prepared), the lines recoiled in such a way that they will run out smoothly and freely when being laid down, and various other necessary jobs done.

Apart from the general marketing of the catches, there was much to interest in the handling of individual purchases for re-sale, and one wishes to-day that the real fish-wife would call at one's door as she used to do, with her basket of real " caller herrin' " or " haddies," which were so much more palatable (or at least seemed to be so as we remember them now) than the fish that have been on ice or in cold storage for many days between the net and the table.

Some of the fish-wives had a simple and satis-

PLATE XI

HERRING DRIFTER RIDING AT NETS

factory method of sharing a purchased box of fish. In the case of two sharing they knelt down at either end of the box and divided it right and left as evenly as they could, taking up a fish in each hand and throwing one on one side and one on the other. When the whole had thus been divided into two, the sharers tossed a coin, or decided by one of many other simple ways which should have the one and which the other portion. It still seems to me to have been a most efficient practice.

But the coming of the motor and the steam vessels has completely altered the methods of the harvesting—the mechanical harvester has almost completely displaced the scythe and the sickle.

To give some idea of the growth of this revolution, it is sufficient to state that in 1906 there were no motor boats and very few steam vessels engaged in the Scottish fisheries, whereas in 1929 there were nearly 2,000 of the former and about 900 of the latter working from Scottish ports.

The diminution of the number of sailing boats in the same period was exceedingly rapid, for while in 1904 there were over 10,000, that number had been reduced by 1929 to just over 3,000.

I am trying to avoid statistics as far as I can, and give the foregoing merely to show the rapidity of the change from the old to the new.

The sea food fishes of commercial value are divided into two main classes: the demersal or the bottom-feeding fish, and the pelagic or the upper-

water types. The bottom feeders, known as "white" fish, are the largest group, comprising the cod, haddock, hake, halibut, skate, sole, etc., all dark or nearly black on their upper side.

The pelagic fish include the herring, which is the most important of all, mackerel, bass, etc., and are all silvery in appearance. The hake is suspected of leading a double life, for when caught on the bottom in the trawl the hake is dark and dull like the haddock; it periodically, however, deserts the bottom pastures and takes to higher waters, where, when caught in the seines, it has acquired a silvery coating like the other pelagic fishes.

There are two main types of nets suited to the two corresponding types of food fishes: the trawl, which "trawls" or "trails" along the bottom and is used by the trawler, and the drift net, which is floated on or near the surface and is fished by the drifter. There are also seines, trammels, and many other types; and there are the liners which catch fish by line and hook, and a great variety of combinations and special adaptations to particular circumstances, but the trawler and the drifter account for the bulk of the fish landings.

The trawl net is a conical bag with open mouth and under-side scraping along the bottom, gathering in the fish as it is pulled along by the ship.

The mouth of the net is kept open, in the case of the smaller vessels, by a long stout pole or beam across the upper "lip," and fastened at its ends to

iron D-shaped runners. To this beam the upper edge of the net is fastened, while the lower is fixed to the runners by a stout rope, curving backwards at the centre and dragging along the ground. This is, of course, hard wear on the net, and the " belly " is generally protected by an extra thickness of netting, canvas or leather.

The opening of the net is therefore determined by the length of the beam and the height of the runners, and these vary with the towing capacity of the ship ; the beams vary from 50 feet in length downwards, and the runners from about 3 feet in height.

As the foot-rope drags along the ground it stirs up the fish, which, rising upwards, are engulfed in the mouth of the net and gradually forced backwards into the bag or cod-end. Here the fish are prevented from escaping forwards by various valve and flapper devices, and when the net is hauled on board the cod-end, which is closed by a lacing device, is opened and the fish tumbled out on to the deck.

The beam trawl is used exclusively by sailing vessels, as these cannot guarantee the uniform speed necessary for the operating of the otter trawl, which is larger and universally used by steam vessels.

The principal difference between the two types of net, apart from size, lies in the method of keeping the mouth open.

In the otter trawl this is effected by means of two large and heavy otter boards, or doors, to which the ends of the top and bottom ropes of the net are attached, and which, being secured obliquely to the towing warps, sheer away from each other when being towed and stretch the mouth of the net to its widest capacity. The action of these doors is similar to that of the ordinary boy's kite, which goes higher the more it is pulled, but the otter boards ride upright on the sea floor.

A trawler can always be distinguished at a glance by the large iron "gallows" on her rail—two on the port side and two on the starboard—through which run the steel warps connected to the doors. The doors themselves are about 8 or 9 feet in length by about 4 to 5 feet in width, thick, and weighing from 10 to 15 cwts. each, the lower edge being shod with thick iron for riding on the ground.

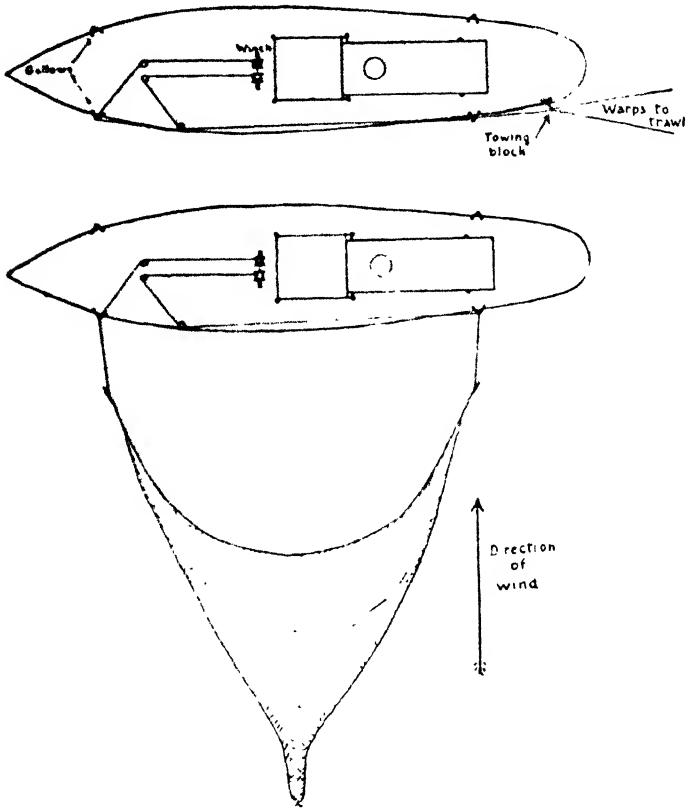
The manipulation of this weighty gear on a trawler is attended by a certain amount of noise, as I have reason to recall. On my first night out I had dozed off into a light sleep (a trawler can be very lively at times, and I had not had time to acquire a sea stomach on that trip!) in my bunk just under the forward gallows. Waking up to find that the engines had stopped, I began to wonder what was happening, when there commenced a series of the most nerve-racking thumpings and bumpings, suggestive of several minor collisions going on at once. Scrambling up on to the deck in the

cold grey dawn of an autumn morning, I was just in time to see for the first time a trawl being "shot." The men were all warmly clad, as they had need be, and wore complete oilskin overalls, which are absolutely necessary for the manipulation of the net. A low freeboard to the ship is essential for the manipulation of the gear, and more often than not the men are knee-deep, and frequently waist-deep, in water part of the time. The operation of "shooting" occupies some fifteen to thirty minutes, according to the depth to be fished, and this may be anything between 50 and 200 fathoms. Once the net is over and adjusted the ship steams slowly ahead, paying out the double steel warp until the net may be as far as a mile behind the vessel. The two warps are brought together and passed through a towing block, as shown on Plate X., and the slow trawling continues for several hours.

When the skipper decides to "haul," all hands are warned, the engineer stands by, the winches are tested and oiled, and preparations made for the reception of the net on deck, while the ship is being brought into the right position; a trawler always hauls on the weather side, so that the wind and drift will prevent the ship riding over the rising net. When trawling, the direction of the wind is immaterial, but for hauling a substantial change in the ship's course may often be necessary.

The first operation is known as the "knock-

out," and one of the hands knocks out a pin on the towing block, thus allowing the two warps to separate and the net to come up square to the ship,



as the accompanying diagram makes clear. The two large winches are now locked together and the warps steadily reeled in until the doors appear. The " quarter ropes," which connect the curving

mouth of the net with the doors, are unhitched and taken to a smaller capstan to be wound up until the net appears on the surface, when it is man-handled aboard as far as the cod-end; a rope is now passed round this and the whole hoisted high on deck, where a "bag-rope" prevents it swinging too far. The bottom of the cod-end is unlaced, and its contents fall into a large, shallow, and top-less box. If the net is undamaged it is shot again, and the ship resumes her course.

The catch must now be sorted, cleaned, and gutted before being put down into the ice-house, the decks cleared and washed, and everything made ship-shape ready for the next haul.

When hauled up from the deep water the net, full of fish, will often float up to the surface on account of the distended air-bladders of the fish, which are subject to the danger of *falling upwards*, an accident to which no other animal is subject.

Many fishes are equipped with an air-bladder, the exact functions of which are obscure; it is probably a reserve supply of oxygen, but it enables the fish to maintain its position without difficulty at its normal depth. When, however, the fish is forcibly taken out of its proper depth, the oxygen expands through the relaxed pressure, and frequently on reaching the surface, the fish is actually burst open. On some vessels, such as the long-distance liners, where prime fish are kept alive in ponds on deck, the air-bladders are pierced by long needles

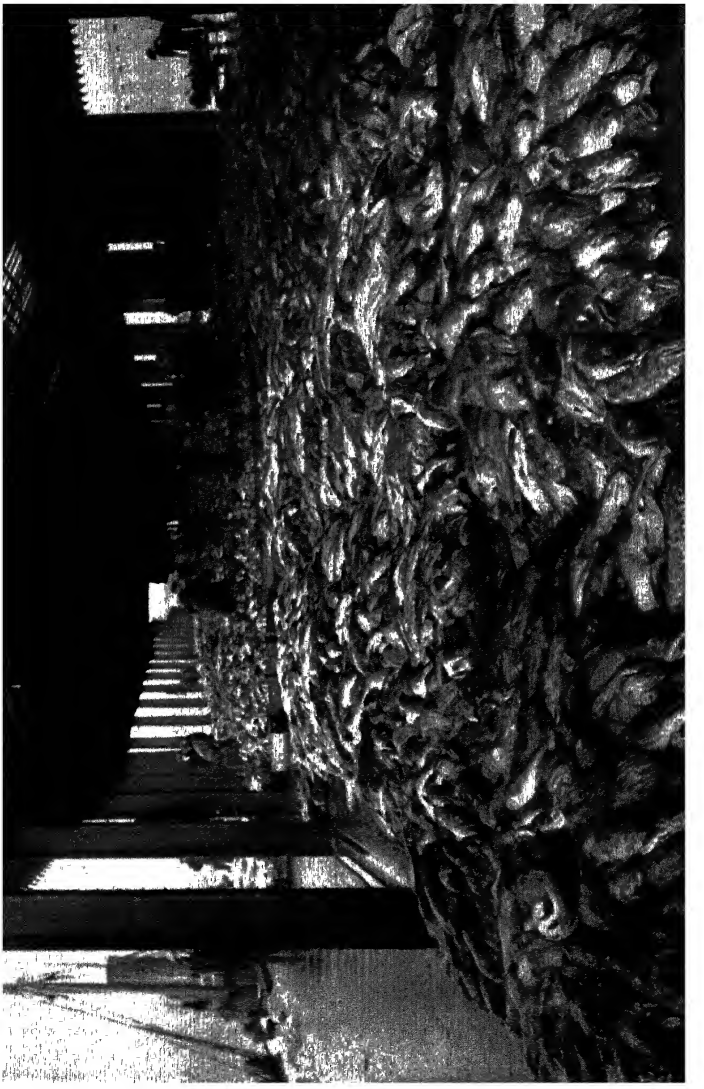
to allow the gas to escape, otherwise the fish would flop about helplessly on the surface and soon die.

A trawler always has two nets ready, so that if one sustains damage the other can be shot at once without loss of time. Damage from rocks and rough ground is common, and worse obstacles, such, for instance, as old anchors—sometimes weighing several tons—are all too frequent. Where such an obstacle is entangled in the net every effort is made to get it on board, not for any commercial value it may have (because the owners get only a share of what the anchors fetch as old iron), but because it is one more source of loss out of the way.

Sometimes when trawling over ground known to be very rough, a row of large wooden bobbins is attached to the belly-rope, and these help to ride over the rough places; so much wear and tear occurs in such cases that these bobbins will lose an inch or more in diameter in one trip.

When watching the net being hauled one very dark night a big rent was observed, but it was not sufficient to put the net out of use if mended at once; the skill and speed with which the first mate repaired that damage on the spot earned my warm admiration.

Almost all the fish taken in the trawl is usable and eatable—jelly-fish, for instance, are not fish—but too many varieties at a time are not looked upon with favour, because a straightforward haul



of cod or other prime fish is much more valuable than a mixture.

Amongst the less familiar sorts are the torsk, top-knot, gurnard, latchet, cat-fish, dog-fish, and angler, or monk-fish. Most of these are palatable when properly cooked, and there is no great harm in our accepting them under more familiar names at the table! After all, one would not care about ordering a portion of cat-fish, though when it appears on the menu as filleted—perhaps I had better not say what!—it tastes better than many more familiar fish dishes.

The torsk (or, as it is generally pronounced, tusk) is a relative of the cod, but does not often grow to more than 3 feet in length. Not much is known about its life history, but the early stages appear to be spent in very deep water. The adult fish migrate to the north of Scotland at the end of the year, and a section enter the North Sea in spring, returning to deep water in summer.

The top-knot is a flat fish belonging to the turbot family, and is found from the Bay of Biscay to the west coast of Norway. Unlike the plaice, the top-knot lies on its right side.

The gurnard and the latchet are nearly related, but the latter is much the scarcer of the two, being only occasionally taken in any quantity. It is sometimes called the sapphirine gurnard, and well deserves the distinguishing adjective. When first brought up in the trawl the latchet's colouring is

brilliant, and the large pectoral fins, for a few minutes until the colour fades, resemble the wings of gorgeous butterflies. These fins are large and fan-shaped, the front rays being separated and forming tactile organs as well as means of progression on the bottom; two-thirds of the fin is rich, bright orange colour, and the remainder, forming a wide outer band, brilliant sapphire blue. When I saw the latchet just out of the net on the trawler's deck, I thought it the most gorgeous thing in sea fish I had yet encountered, and when, later, the steward had served it up (baked, with sage and onions!) for dinner, my admiration was fully confirmed.

But what is the purpose and value of such colours in deep water, where colour rays of light do not penetrate?

The dog-fish and the cat-fish have already been mentioned, but the fishermen do not like them, especially the former which generally appear in packs and seem to scare away other and more valuable fish. The angler or monk-fish (and known by many other names) is of little commercial value, being mostly head and mouth! It is a sluggish, lazy creature, living on the bottom and waiting for food to come to its mouth instead of hunting for it. The front rays of the dorsal fin are greatly prolonged, and end in a loose piece of skin like the bait on a hook; this bait is dangled by the fish in front of its capacious mouth, and when hungry or inquisitive creatures nibble at the bait they are taken inside.

The jaws of the angler are furnished with a double row of sharp, hinged teeth, which offer little resistance to ingress, but are an effective barrier to egress from the trap. In some of the deep-sea types the bait, and even the teeth, are luminescent. The best one can say about this fish is that it has a fine open countenance!

An early morning visit to a large fishing port such as Grimsby or Aberdeen is well worth while if one is at all interested in fish. The trawlers have crept in, or struggled in, during the night, and the work of landing and sorting the fish has been proceeding since a very early hour. The quantities which can be dealt with in a short time are surprising to the layman. One day in Aberdeen, after spending the morning at the harbour, I looked at the evening paper to see how the fishermen had been treated by the market, and read that "prices ruled high, and only 170 tons had been landed." What a toll to take from the sea every day!

Close by the fresh fish warehouses, the curing establishments and the offices at the quay side, are factories for dealing with the offal and occasional lots of fish which, on account of the small size, inferior quality, or other causes, prove unmarketable. The principal by-products are fish meal, guano, industrial and medicinal oils, and glue. The best medicinal oils are made from fresh cod livers, and from inferior material stock-fattening and industrial oils are produced.

Experiments have been made with a view of producing a fish meal suitable for human consumption, but these do not appear to have been successful on a commercial scale.

At smaller ports there is inevitably a good deal of waste, for fish deteriorate very quickly after being freed from the preserving ice.

The gradual increase in the size and capacity of the fishing vessels has naturally led to longer voyages, so that much of the catch is far from being "fresh" when landed, and the subsequent exposure, delay in transit, etc., cause rapid depreciation.

In some authoritative quarters the need for better means of preservation is urged as essential; and probably the extension of the factory-ship system, whereby the fish can be prepared for immediate sale and consumption before being landed, along with improvement in preservation methods, will reduce waste and increase efficiency.

But it would seem more desirable to improve and accelerate means of distribution, so that the fish can be delivered fresh to the consumer, who nowadays scarcely knows what really fresh fish is, unless he lives near where it is caught. The development of the system of dispatching small parcels of fish direct to the consumer from the fishing ports offers considerable scope and promise; and the increasing use of road transport to inland villages and towns is all in the right direction.

The Herring Drifter (Plate XI)

The lowly, and often despised, herring is, commercially, the most important of all marine food fish, and no other fish in the sea is caught in such great numbers. One boat may catch over 100,000 herring in one day, so that at such a port as Yarmouth 20,000,000 to 30,000,000 of herring may be landed in a day.

But for its almost incredible powers of reproduction (a herring hard-roe may contain more than 20,000 eggs), and for its ability to adapt itself either to surface or bottom feeding, the herring must long ago have become extinct.

Instead of that it persists in such quantities that in some seasons the fishing fleets have to retire from their work because the market cannot absorb any more fish, and not because there are not still plenty to be caught.

The race is not always to the swift nor the battle to the strong, for the herring is not endowed with special weapons of defence or exceptional powers of movement; but its cohorts as they speed in purple and silver through the green kingdoms of the sea must be considered in terms of cubic miles for bulk and thousands of tons for weight.

The inroads of the fishing fleets seem to make little or no impression on the main stock, but their movements and migrations are still largely unaccountable. The herring is almost the most

difficult of fish to work upon scientifically, for they spawn all the year round, and some spawning herring are to be found somewhere at any time.

The chief time for catching herring is when they are approaching the coasts in dense shoals to spawn, and this is probably determined by the temperature of the surrounding water.

The great drift-net fishery starts on the west coast of Scotland in early spring, and the fish appear at different localities down the eastern coast in summer; by July Scarborough and Grimsby become the chief centres, and by early autumn the great East Anglian fishery is in full swing. Many of the boats follow on until the end of the year, or even the early months of another year, finishing up at Plymouth.

Formerly it was considered that the southward trend marked the migration from the Arctic waters of the great herring army, beginning to impinge on our coasts at the north of Scotland, and gradually working south, but this view is not now generally held. Much careful research and investigation, extending over many years, and not confined only to this country, but carried on largely also by Norway, has established that the age and growth of the fish can be computed from examination of their scales, and that quite different shoals and schools are engaged in making up the sum of the great general movement. Probably fish of different ages emerge in separate shoals from deep-water recruiting grounds and retire to them again after spawning,

and these grounds may be near or far away, according to the age composition of the shoal.

Each shoal is composed largely of fish of the same age, and in some manner these appear to keep together and not to mix with other shoals. One drifter will land a catch of full-roed fish, whilst another, fishing near by, will have only spent fish.

A very able investigator, who has been on herring research for many years, confessed to me that he was at a standstill and felt he could get no further forward until, like Kipling's captain, "he had a mind like a herring and could think like a herring."

The spawning grounds of this wonderful fish are therefore along our eastern coasts, and to a large extent have been determined by the finding of shoals of "spawny" cod—fish that had congregated on these areas to feed on the herring spawn, and when caught were full of it!

Seasonal drifts carry the helpless young fry southwards, and tidal currents bring them into estuaries and bays in huge quantities. The "whitebait" shoals of the Thames estuary are mainly composed of young herring, from three to nine months old, the remainder being small sprats, sand eels, and a sprinkling of other fry. Their first migration to deeper water is probably not a long one, and succeeding journeys will take them to more distant resting places; possibly the mature fish may even make for the open ocean, but we do not yet know.

The " drift " or gill nets used for the capture of pelagic fish, such as the herring, mackerel, pilchard, and sprat, are in principle vertical walls of netting, set to float with their upper edge on or near the surface, and their lower edge weighted to sink. Any fish that strikes this wall of netting will become caught in its meshes, unless the fish is too small and can pass right through, or too large and cannot get its head in far enough. Either the fish's head is jammed tight in the mesh or else gets through beyond the gill covers, when the cord, catching behind the slightly raised gill cover, prevents any backing out.

The drifters are smaller than the trawlers, and are not usually fitted with gallows or trawling winches, though some are so fitted so that they can trawl when the drifting season is over. The nets are made in sections joined together, so that the total length of netting may be as much as 3 miles or more. A strong foot-rope connecting the nets at their lower edge is necessary, for the strain in hauling such a mass is very great. The manual labour of hauling is also very great, and the men have frequently to change positions with each other in order to get relief by a change of movement.

The depth at which the net is fixed is often a matter of personal judgment on the part of the skipper, and when fished at any distance below the surface the upper edge is attached by strong cords to buoys or floats.

At about a couple of hours before dark the nets are shot across the tide and the ship rides at their head (Plate XI) with her mast-head lights showing all moving craft on which side they must pass; the whole then drifts with the tide until about dawn, when the nets are hauled by steam power over special rollers and the fish shaken out.

The process of landing, gutting, salting, and packing of the fish are too familiar to many to call for description here, but they give employment to an army of workers on land, amongst whom the Scottish "gutter girls" are always prominent. The work calls for a high degree of skill, and also of endurance, especially in the winter months, but it is healthy and remunerative.

There was a time not so long ago when the Scottish girls could readily be singled out in the streets of East Anglian ports, but a Lowestoft friend tells me that they are now indistinguishable from the local "flora" until they begin to speak!

A certain amount of trawling for herring is carried out on some grounds, but in the main this is done by German boats; the native fleets are almost entirely composed of drifters. This trawling takes place in daylight when the herring are at or near the bottom, but the fish so caught are not so valuable, because they cannot be landed in such good condition as those from the drifters. The herring is a delicate fish, and when trailed along the ground in the cod-end of a trawl net, quickly de-

teriorates in appearance and condition, whilst the greater freedom of gill-caught fish allows of them being landed at their best.

The daylight trawling for herring has recently brought into prominence the tunny as a sporting fish, and some very large specimens have been captured on rod and line off Scarborough. This does not imply any new appearance of tunny in the North Sea, but a new recognition of the fact that they are there. Formerly many of the fishermen did not recognise these monsters and called them dolphins, or even sharks, when they followed up the nets and gobbled up stray fish, and of course the drifters working at night would see little of the marauders.

Tunny seem to be expert in dodging the trawl, or else they seldom swim on the bottom, for they are very rarely caught in the net. In the Mediterranean the commercial fishing for tunny has long been, and still is, of considerable importance, and I have an old print showing the final round-up in the nets and final slaughter. This scene is gory in the extreme, the entire human gathering appearing to have gone mad with the lust of killing.

Albacore and Bonito belong to the same family but are not found in our waters; the common mackerel, however, is a near relation.

Tunny are common in the Mediterranean, and it was long held that they migrated there from the Atlantic; probably they do, but it seems likely

also that many winter in the depths of the Mediterranean on returning from eastern waters.

The general life history of the mackerel type appears to be first the helpless drifting of the eggs and newly hatched, then a gathering on the recruiting grounds, migration shorewards in summer and seawards in winter, the passing into spawning contingents, and a continuation of seasonal migrations over longer periods and longer areas.

Normally tropical fish, the mackerel and its ally the tunny proclaim by their silvery coating, graceful shape, and forked tail that they live mostly in the upper waters, and are fast swimmers. The general movements of the tunny, therefore, would appear to be: the young are gathered in shoals during immaturity, and migrate to a limited extent, but at maturity they break up into small groups after spawning and roam far and wide—even into the North Sea—until the call to reassemble for spawning brings them back again.

A curious use of imitation or dummy tunny fish by the Norwegians in some of their herring fisheries connects the two fishes by another link. In deep-water bays, or in deep channels between islands and the shore, herring shoals can be hemmed in by the use of lengths of netting, and carefully shepherded for days or weeks while preparations for securing them, finding purchasers, transport, etc., are going on.

When a shoal is sighted from shore or from a look-

out boat, the whole of the fishing community acts in co-operation, and every serviceable net, rope, buoy, etc., is brought into use. The primary object at first is to surround the shoal on the seaward side and bring it into shallow water with as little loss as possible. The shoal may be of considerable extent and unevenly distributed, but it is possible, by means of a thin cord with a lead attached to the bottom, to feel the fish, and a skilled man can judge by this method the density of fish at that spot and whether it is the main shoal or a flanking party. If the latter, efforts are made to improve the concentration, and in these the dummy tunny is used much as a shepherd utilises his collie dogs for gathering in his flocks of sheep. The dummy fish is made of wood, heavily leaded at the head, painted white, and a cord attached to the tail. It is roughly fish-shaped, and about 4 feet long; when thrown in head first, the dummy slithers along in an irregular line until the throwing force is spent, when it is recovered by the cord and the operation repeated. The supposed appearance to the fish of their chief enemy sends them off in the desired direction, and the rounding-up is continued until the whole mass is compactly gathered together. A great expanse of netting is often necessary, and if the complete operation is extended over two or three weeks, as it may be, it is necessary to lay down a second net inside the first and lift that for drying and redressing for preservation, else it would rot from long immersion.

Curiously enough, the herring often improve in condition from this long confinement, as they become cleansed from some kinds of open-sea food which would otherwise affect their commercial value.

It is an anxious time for all concerned, for buyers have to be fetched and a transport ship arranged for from some port, possibly even an English ship. The buyers examine the fish by means of water telescopes, and contracts are made on the strength of such inspections before the fish are taken up. Sometimes, too, the owner of the island takes an interest in the affair, and rows round to form an idea of what his share of the proceeds should be!

When preparations are complete a "cast" is made by a small seine net inside the main enclosure, and this smaller circle is drawn into shallow water where the empty boats are waiting to be filled. With a good haul to deal with, the men in the boats will be standing thigh-deep in a mass of herring while they fill the baskets and boxes let down from the ship.

Pilchard fishing in Cornwall has some resemblance to the foregoing, just as the pilchard itself and the herring belong to the same family. The look-out man on the headland was called a "hue-er," and his shelter the hue-er's cottage. Here he watches eagerly for the first signs of the pilchard shoals, and on sight raises a "hue and cry" for the fishermen waiting in the bay below, directing them on the water by signs towards the fish.

There is not a great deal of difference in appearance between the pilchard and the herring, though the former is generally shorter and has a body less deep and more rounded. The back of the pilchard is olive green, as against the herring's blue, and the scales are larger and thicker. The gill covers of the pilchard are distinguished by fine lines, radiating fanwise from the back of the eye, and the dorsal fin is nearer to the head than in the herring. If a fish of each kind is held by the dorsal fin, the pilchard will balance in a horizontal position while the herring will dip by the head.

The pilchard is the mature sardine, and is common also in the Mediterranean, though smaller there than in the Atlantic. It is restricted to the coastal waters of the Mediterranean and the neighbouring Atlantic coast from Madeira to the south coast of Ireland, and the Channel as far as Start Point in Devon and Cherbourg in Manche. The mature fish may wander into the North Sea, but never in any numbers. Spawning appears to take place offshore in summer, and the spent fish retreat to deep water in the winter; the growth of the young is rapid, and the sardines of commerce are from nine months to two years old.

These sardines visit our shores just as they do those of the Mediterranean, and the home variety is actually superior to the French; but even if a sardine fishery here should somewhere succeed (and probably some of the many attempts to estab-

lish one are still alive), in spite of the short season, there would still be that strange prejudice in favour of the foreign article to be overcome before the better quality of the home product would be appreciated.

Pilchards, like herrings, have long been unjustly depreciated as an article of diet, and probably the aspersions on their flavour which have found expression in such sayings as, " Pilchards is like wimmin ; when they'm bad they'm awful, and when they'm good they'm only middlin," originated with some disgruntled old Cornishman to whom a too regular succession of meals consisting of pilchards and potatoes, varied only by potatoes and pilchards, had become as monotonous and unappetising as the salted herring, or the red (smoked) herring of the Scottish and Irish villages.

There is no good reason why the pilchard, properly prepared, should not be better appreciated ; its flesh is firm and its flavour admirable ; it is nutritious and cheap—perhaps too cheap. If pilchards and herring were as scarce as sole or salmon there would be less prejudice against them, based either on hearsay or a dislike at first trial. After all, what epicure really enjoyed his first oyster ?

The Long-Liners

There seems little of romance about this particular branch of the business of going down to the sea in ships, the fleets that go to distant northern waters

to gather their share of the harvest by means of lines and baited hooks.

Probably the very earliest means employed to capture fish was the use of a pointed spear, and the discovery that a miniature spear, a thorn hidden in a bait, would stick in a fish's throat when it was feeding came later, and led to hooks and lines in due course. What a fine time the grousers of those old days must have had when an enterprising youngster, armed only with the new-fangled gear of a few yards of fibre, some pieces of meat, and a few thorns, showed a good catch! "If this sort of thing is to be allowed to go on there will soon be no fish in the sea," etc.

But worse was still to come when it occurred to someone to build a substantial barrier across the mouth of a creek to imprison the fish that had run up with the tide; the barrier would keep the fish back while allowing the water to escape as the tide ebbed again. From that to a temporary or removable barrier and then to a portable one, as better material and methods were employed, was the inevitable path to the different forms of nets as we know them.

The hook and line fishing is still an important branch of the industry, but the deck of a long-liner in Iceland waters on a cold wintry morning, with a heaving lift in the sea, a sky banked with lowering clouds, wind with a razor edge sharpened on an iceberg on the horizon, and spots of rain or snow

stinging the face, is not usually associated with romance, but rather with bitter hard work and constant, uninviting exposure. So are bred the hardy types that man the ships making long voyages to those distant seas in search of large cod, haddock, hake, halibut, turbot, and many other prime varieties.

Only the sturdiest of seagoing fishing vessels are suitable for this work, for they are subjected to much buffeting; they must also be capable of carrying enough coal for two or three weeks' steaming. Some of the larger trawlers are converted into liners, the typical gallows of the trawler being removed and additional deck gear being fitted for the manipulation of the long lines. The large winches which carry the trawl warps may be retained on the liner and utilised for the anchor chains, smaller quick-action capstans being provided for the winding-in of the lines, which may extend to 12 or 15 miles in use at one time.

Another distinctive feature of the liner is the large storage tanks on deck in which the prime fish are kept alive, fresh sea water being pumped into these tanks at regular intervals. I have heard it stated that a cat-fish is kept in each tank in order to keep the other fish moving about, but that, if it is ever done, can only be a kind of fetish, because fish hauled up suddenly from their deep-sea home and crowded together in a tank can hardly be seriously worried by the presence of an undesirable neighbour.

The fishing equipment of a typical liner consists of twelve dozen lines made of Italian hemp, each line being 40 fathoms in length. There is a hook every 16 feet, attached to a "snood" of thinner line 5 feet long, which in turn is attached to the main line.

About two-thirds of the whole equipment of line is in use daily, weather permitting, and it will be realised that a "shoot" of such dimensions keeps the men busy.

Herring is the bait chiefly used, and these are taken on board as late and fresh as possible, often at such northern ports as Peterhead.

When on the fishing ground the inward end of a long line is fastened to a large float, called a "dan," and at night the top of the pole of the dan carries an acetylene lamp.

Hauling the lines is assisted by an arrangement of rollers called a fair lead or fishing jenny, and long-handled gaffs are employed to get the big fish aboard. Some of the halibut thus taken are very large fish, comparable in weight with the men who handle them.

There are always uncommon fishes to vary the catch, such as the bright red "Norway haddock," as it is commonly called, though in Hull it is "bergylt," or "soldier," and in Aberdeen "red barsel." The scientific name is *Sabastes Norvegicus*, and when newly caught its colour is very bright—between vermilion and red madder. It is one of the few

bony viviparous fishes, and the average weight is about 4 pounds, though specimens up to 20 pounds have been recorded.

Occasionally a large Greenland shark visits the neighbourhood of the liner and proceeds to swallow a number of the fish already hooked, and so conveniently tethered for a shark's feast. But the hooks cannot be ejected, and the combined lines are strong enough to enable the shark to be hauled to the surface, when ropes are passed round it and it is hoisted on deck. Most of the shark can be turned to profitable uses, especially the large liver, which yields a considerable quantity of oil, valuable for tanning and currying leather. Smith minor would assert that tanning leather is the only fit use for any fish-liver oil!

Some of the large rays, near relatives of the shark, also yield valuable commercial oils from their large livers, and some medicinal oils also. On one occasion I saw a deck hand on a trawler put aside a skate from the general sorting of the catch, and at his leisure proceed to cut out the liver and put it into a large tin. Wondering what particular object the man had in this, I asked him, and was told that the oil of that particular type of liver had wonderful healing properties, and was in great demand for cut or bruised hands and fingers. It probably was, in its way, as efficacious as cod-liver oil, and certainly it looked just about equally uninviting!

It would be impossible, within the limits of this

volume, to describe all the various types of fishing vessels and the different methods of fishing, but one other of the larger divisions of the industry may be mentioned here.

The great London fish market at Billingsgate draws its supplies from far and near, and they come by rail, by road, and by sea. The fishing vessels whose catches are dealt with in London do not come directly into the Port of London, but transfer their fish at sea to fast carrier vessels, which steam right up to Billingsgate to discharge their cargoes. The "fleeters," as they are called, and the carrier ship, rendezvous at an appointed place and time, and the boxes of fish are lowered into boats, which are rowed to the carrier. The carrier does some fishing, too, but is equipped with one net only, leaving one side of the ship clear for the hoisting on board of the boxes. This is an exceedingly hazardous branch of sea fishing, and accidents are, unfortunately, very frequent. It is difficult enough in calm weather to lower heavy boxes of fish from the deck of a trawler to the waiting dinghy and hoist them from there on to the carrier vessel, but in rough weather the difficulty is increased into actual danger, and many bruised and broken hands and fingers result. An experienced trawler skipper told me emphatically that there was scarcely a man engaged in that work that had a whole hand.

The ships of the Mission to Deep-Sea Fishermen attend to many of these accidents, and that organisa-

tion is worthy of all the support we can give it. When the carrier has collected all her cargo, she hurries back to Billingsgate and the trawlers resume their labours.

Shell-Fish

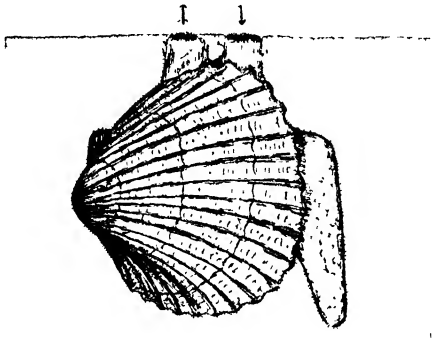
Under this heading are classed together lobsters, crabs, shrimps, prawns, oysters, mussels, cockles, whelks, periwinkles, and other edible sea animals, and none of them is a fish. We have no comprehensive and suitable names for these minor portions of the sea's harvest, for neither molluscs nor crustaceans is a handy term, and so we continue the inaccuracy.

The edible cockle is familiar to us all, and some of the cockle fisheries, such as that at Leigh, in the Thames estuary, are important industries, preparing and marketing large quantities of valuable foodstuffs.

The cockle is exceedingly common, usually living between tide marks, just buried in the sand or mud where there is a sheltered stretch. The young float about in the water, and are carried far and wide by current and tide; surviving when the ground on which they finally settle is capable of providing for them, sometimes in such vast quantities that the "seed" cockles, as they are called, form a complete layer in the sand. This in turn attracts and sustains many small fish, especially plaice and other flat fish, whose chief food consists of small molluscs.

Gulls and other sea birds also take large toll of small cockles, while the star-fish and the whelks get a share.

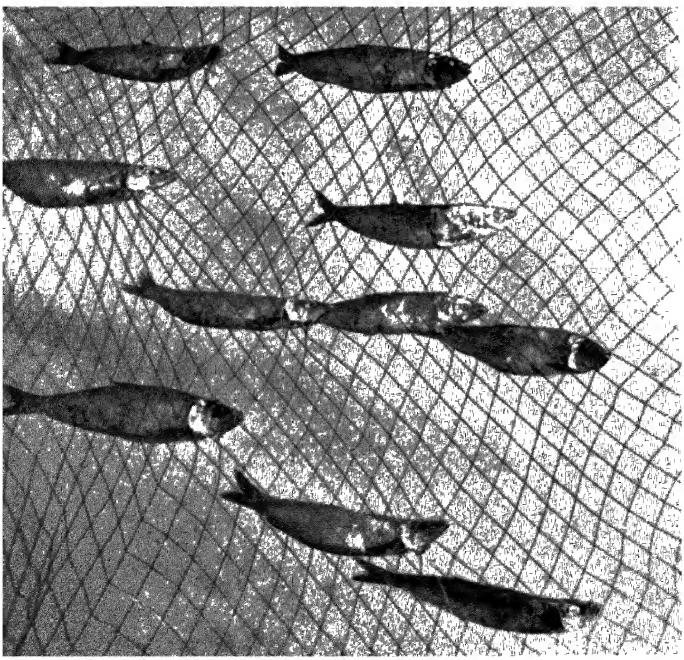
The average cockle-shell is about an inch across, and there are local bye-laws regulating the size of the meshes in the riddles employed at the fisheries, so that the smaller cockles may be returned and allowed to grow to marketable size.



Cockle buried in Sand

The shell of the cockle reveals its age in a manner similar to the scales of a fish, as shown earlier—*i.e.*, feeding, and consequently growth, is greater in the summer than in the winter, and is reflected in the wide summer zones and the narrow winter rings on the shell. But, as with scales, these rings or checks may be due to causes other than cessation of feeding growth, and may be the outcome of abnormal conditions or happenings, such as storms or exceptional exposure to summer heat.

PLATE XIII



HERRING DRIFTERS RETURNING TO PORT WITH THEIR CATCHES
HOW HERRING ARE CAUGHT IN A DRIFT NET

The cockle lives in the sand, just under the surface, and has a strong muscular "foot," which is thrust out between the shells and employed for digging into the sand and for moving from one place to another by little hops. It does not feed on anything in the sand, but strains out minute animal and plant cells from the sea-water, taking it in by one syphon and ejecting the unwanted liquid by the other.

They can be scraped up by hand or by rakes and other metal implements. After they have been gathered, washed, and riddled, the cockles are steamed in large ovens; this sterilises the animals, opens the shells, and loosens the fleshy portion, so that when placed in large swaying riddles the soft parts will pass through and be prepared for sale, while the shells are retained and form huge heaps. Sometimes it is practicable to utilise the shells by grinding them up into grit for fowls.

Mussels

Classed also among shell-fish, although not a fish at all, the mussel is a valuable item in the national food supply, and very large quantities are harvested yearly and consumed.

Unlike the cockle, which has a strong foot and can jump along on the sand, the mussel is capable only of a very limited amount of movement—just so much as it can secure by hauling on or slacking off the fibrous cable with which it attaches itself

to pier or rock or other stationary object. This fibre is woven by the mussel, and is not of vegetable origin.

The young are developed inside the shell, and when ready to be launched on an independent life are shed from the parent shell as minute, free-swimming larvæ. These, after a few hours in suspension, settle down on the nearest solid substance, and remain there. The fresh-water mussel ensures the distribution of her young up-stream by releasing them when minnows or other small fish are near. The mussel appears to react to the presence of the fish, and releases her brood so that some of them alight on the fish and are carried whither the fish go, to fall off later and take up their stationary abode.

Mussels have been unjustly blamed for spreading disease, and even for causing it. At the worst they have been innocent carriers of disease germs, not the originators of them. In one district an epidemic of typhoid fever was traced to the eating of mussels, and laboratory experiments proved that the disease germs were present in substantial numbers in the mussels taken in that district. What had happened was that the mussels had absorbed water from the estuary draining the infected area, and that water contained the disease germs. Thereupon the fishery was closed and a number of men thrown out of work. The Government department concerned established a mussel-cleansing station, which operated in the following manner :

The mussels were first spread out on grids and subjected to a thorough washing. They were then immersed in a bath consisting of the estuary water plus a minute percentage of chlorine. No matter how small the percentage of chlorine (less than 5 parts in a million), the mussels refused to function and kept their valves closed. It was then found necessary to neutralise the free chlorine with hyposulphate of soda, and this enabled the mussels to function and at the same time to get rid of all waste matter, including the fever germs. A further chlorine bath shut the mussels up again, but effectually sterilised their shells, and finally the now immune shell-fish were packed in sterilised bags and safely sold for human consumption.

Fresh-water mussels frequently form small pearls (see Plate XV), probably deposited over small parasites which enter the shells. In the summer holidays I, as a boy, used to indulge in pearl fishing in our home river, which was crystal clear, and in which mussels could be distinguished from stones at considerable depths. The equipment consisted of a borrowed boat, one of mother's clothes-props, with a clothes-peg securely fastened to the end, and a large biscuit tin minus the top and bottom. The last item was for cutting off the reflected and refracted light, so that with one's head inside the tin, and that just breaking the surface of the water, one could see to the bottom quite clearly. The mussels were located, secured by the split peg, and

opened later; the latter operation generally involving much labour and yielding little reward.

The sea-mussel sometimes takes in a lodger in the form of a small pea-crab (see Plate XV). This is a very old habit, so old that in course of time the crab has lost all its crustacean characteristics, and no longer has a hard shell, but all sharp edges and rough places are polished smooth so as not to injure its host. The crab is not, strictly speaking, a parasite, as it does not feed on its host nor apparently molest it; but contents itself with sharing the food which the mussel strains from the sea water. The male pea-crab retains his outdoor independence and his protective armour.

The illustration of the mussel and pea-crab shows the latter on the outside of the shell, as against the light-coloured interior the crab did not show up sufficiently well. This shell reveals a state of over-crowding common in shore waters, where the struggle for existence is keenest. On the mussel is a saddle oyster, on the oyster a barnacle, and on that several tube worms.

Oysters

In the under-water kingdom the oysters are the aristocrats of the shell-fish community, not only because they stand so high in the estimation of man today, but because one can trace their ancestry back into the dim recesses of early history.

Many of the ancient writers refer to the oyster.

Sallust (50 B.C.) says, " The poor Britons . . . there is some good in them after all . . . they produce an oyster." One wonders if that shows a high estimate of the oyster or a low one of our ancestors.

Juvenal (A.D. 60) records that oysters were in high repute among the luxurious Romans.

Dr. Baster, quoted by Dr. Johnson, seems to think that the Romans were wise in their liking, for he says, " Living oysters are endowed with the proper medicinal virtues; they nourish wonderfully, and solicit rest; for he who sups on oysters is wont on that night to sleep placidly; and to the valetudinary, afflicted with a weak stomach, oppressed with phlegm or bile, eight, ten, or twelve raw oysters in the morning, or one hour before dinner, is more healing than any drug or mixture that the apothecary can compound." This mode of acquiring an appetite for dinner still survives, and an eminent living authority on natural history says that the oyster " pulls the trigger of digestion." Judging from the number of empty shells one sometimes sees on the dining-table, it would seem that the trigger must be pulled a good many times to be effective! We have not, however, yet advanced from the primitive habit of eating live oysters!

Another historical allusion is to be found in the records of evidence taken on oath in a Committee of the House of Lords in 1866. It is there stated that " The Whitstable Company are a most ancient body of 'free fishers and dredgers' who, from

father to son, have carried on the business of an oyster fishery for, it is probable, a period of at least two thousand years. It was about A.D. 80 that oysters were first exported from the neighbourhood of Reculvers to Rome, and for the ancestors of the Whitstable 'free dredgers' Rome was their Billingsgate."

So much for the oyster's claim to aristocracy by long and honourable lineage, and now for a little natural history which is no less remarkable.

During the months of the year that have no "r" in them the oyster is protected by law; actually, however, the legal protection ends early in August, and its continuance to the end of the month is a commendable piece of co-operation among the oyster fisheries.

During the close period the oyster is said to be first "white sick" and then "black sick"; the darker appearance of the later stage being due to the presence of food in the embryo and the further development of the minute shells.

If you scrape a piece of slate pencil with a knife, and let the resulting dust drop into a glass of water, you will get a very good imitation of oyster "spat"—the embryo oysters, shed from the mantle of the parent shell. Each such speck of matter is a living organism, with quick-moving "feelers" that are visible only under the microscope. The number of such units is enormous—over a million to each adult oyster.

For some hours this "spat" is in suspension in the water, and is subject to many forms of destruction. If there is much wind, the spat may be carried out too far to sea and lost, or carried over to positions where there is only mud or weed for it to settle upon. All the time it is part of the plankton of the sea, the food of numberless fishes, the "sea-soup" of young life in the sea.

Under favourable conditions the spat falls on to previously-prepared beds, and this is where careful cultivation comes in. The oyster beds need "making" in a very real sense, and much care and thought go to the job. In the main, reliance is placed on clean, empty shells; but there are elaborate porcelain articles used, also old lobster pots, bundles of faggots, and many ingenious forms of sea equivalents for sheets and blankets (see Plate XIV).

By late autumn a strong magnifying glass will enable you to detect the year's spat in the form of minute bright specks; these specks will in the next year be visible to the naked eye. In the third year the young oysters are separated from the "cultch" and from each other, and relaid on the beds.

In the fourth year they are known as "half-ware," and in the fifth year they are really "oysters."

Even after the spat has grown into an adult oyster there are many enemies lying in wait for it; chief among those enemies is the star-fish, the ordinary "five-finger." The star-fish simply en-

circles the oyster, and when the latter is forced to open its valves the former sucks out the oyster and rejects the shell. Another enemy of the oyster is the common whelk, which drills a neat hole clean through the oyster's shell and then sucks out the contents; and crabs take their share.

The oyster is immobile and cannot get out of the way of its enemies. Unlike the cockle, the oyster has no foot with which to propel itself; nor has it a head or eyes, but otherwise its make-up is complex and wonderful. The creature breathes and feeds simply by opening its shell and taking a gulp of water. From this water a marvellous system of hair sieves holds back the microscopic atoms of food, and then the water is expelled from the shell.

In recent years a new enemy has appeared on the oyster beds and become very troublesome; this is the slipper limpet, which seems to have been imported into this country from America in consignments of young oysters used for relaying. The supply of native oysters is quite inadequate, and large quantities of immature stock are imported for fattening in home waters; shallow, muddy creeks abound in suitable food, and there the oysters are laid down to grow to marketable size. The limpets do not attack the oysters directly, but they multiply at a very rapid rate and absorb quantities of food to the oyster's detriment. These limpets have the curious habit of roosting one upon another, and

little piles of six or eight, or even more, are frequently found. Apparently the sky-scraper habit extends even to American shell-fish! So great a nuisance did they become at one time that a crushing mill was set up to turn the shells into something useful—chicken grit in this instance.

With all these enemies to overcome, and with all the careful handling necessary to their well-being, it is surprising that oysters are not dearer to buy than they are now.

Shrimps and Prawns

Amongst the smaller crustaceans shrimps and prawns form a substantial item, and are gathered and sold in considerable quantities.

There are two varieties of the edible shrimp and one of the prawn which are taken around our shores, and there is often confusion between the shrimps and prawns. The following drawings and description should clear up any difficulty in the way of recognising the different species.

The common brown shrimp, when alive, is sand-coloured and speckled like the sand in which it lives; it is difficult to see because of its colouring, and also because of its habit of burying itself in the sand, leaving only the long feelers exposed. When boiled the familiar brown colour appears.

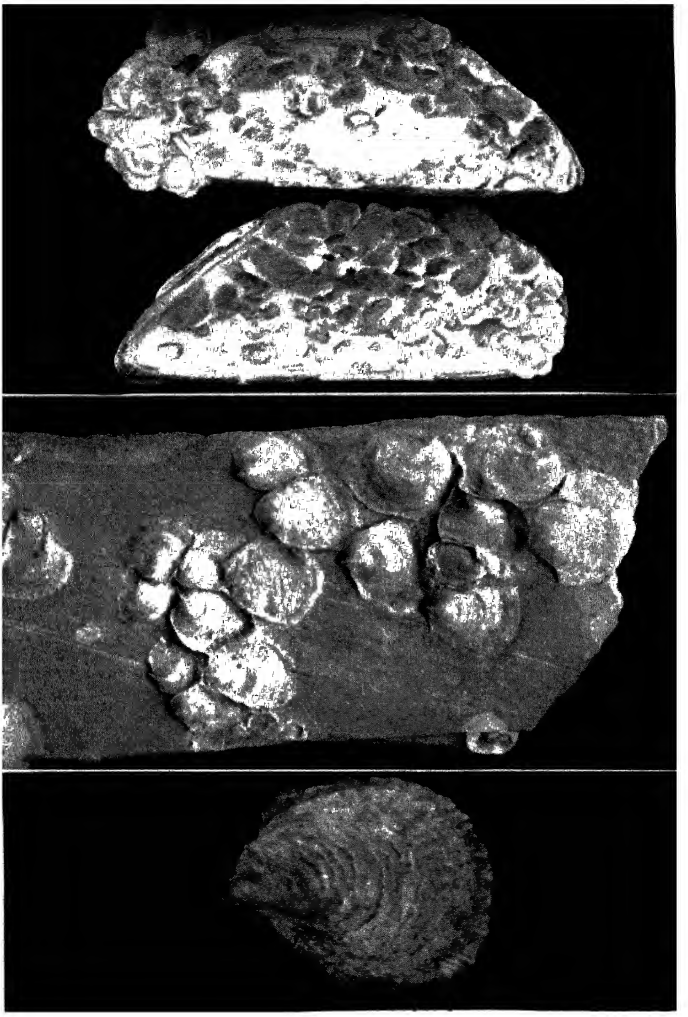
The brown shrimp has no toothed rostrum, the front end of the carapace being short and blunt (3); it has one pair of small pincers (1) of peculiar shape,

may be clinging to limbs or antennæ. The prawn feeds mostly on dead animal matter, but is most cleanly in its habits.

Catching shrimps in large nets pushed along the sand forms an industry of some importance in several parts of the country; in other districts a shrimp trawl is drawn behind a horse and cart, while in deeper water sailing boats, which are really small trawlers, are employed. Of course the net that will take shrimps will also take small fish, and inevitably a good deal of waste is caused by the destruction of small fish in this way, even when the net is hauled frequently and the fish sorted out and returned to the sea, for most of them will have been killed by being dragged along in the net.

Lobsters, crabs, crayfish, and other crustaceans and molluscs form part of the sea's contribution to our food supply, and as some of these exhibit interesting habits and peculiarities, I will deal with them in the next chapter when describing fishery research.

I should like to close this survey of the commercial side of fish life by recalling the human aspect of the industry. At best the fisherman's life is a hard and dangerous one, deserving our consideration and our sympathy. When the wind howls round the house on a winter night we might, from the security and comfort of our bed or fireside, echo the sentiment contained in this verse which I quote from a "Fisherman's Child's Lullaby," by that charming



OYSTER SPAT ON MUSSEL SHELLS
SMALL OYSTERS ON PIECE OF SLATE
A NATIVE

(*See pages* 105)

American writer, Dr. Henry van Dyke, in his delightful book, *Fisherman's Luck*:

"Far away, my bonnie boatie,
Roaring winds are white with foam.
Ships are striving, onward driving,
Day and night they roam.
Daddie's at the deep sea trawling,
In the darkness rowing, hauling,
While the hungry winds are calling—
God protect him, little boatie,
Send him safely home."

CHAPTER IV

ANIMAL LIFE ON THE SEA FLOOR: FROM THE GREAT DEEPS TO THE BEACH

It is a strange reflection that although more than half of the earth's surface is covered by water, we know very little indeed about either the water or the earth it covers. Even those of us who live with the sea at our doors, or who go down to the sea in ships, know little or nothing beyond the beach on which we can walk at low tide, or the surface which furnishes a not always pleasant means of transport between one place and another.

On a calm day, in clear water, we can sit in a boat and peer down upon the sand and rocks, watching the animals crawling or swimming there or amongst the seaweed; but, generally speaking, our acquaintance with the sea floor ceases at a fathom's depth.

And does the traveller or the sailor know much more than that? To him the sea's surface may be familiar in all its aspects of calm and storm, and the deep blue water of the open sea an old story; but what of the middle depths, or the bottom, 500 or 5,000 fathoms down? What is it like; is there life there or only death and corruption?

No one has ever seen the bottom of the sea or ever can see it; the only means of making its ac-

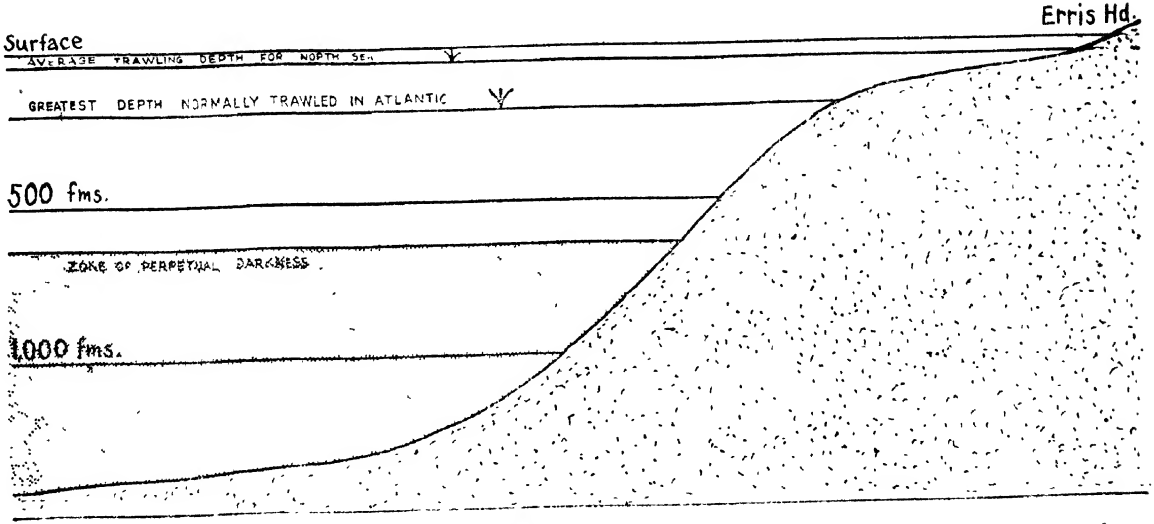
quaintance is to examine portions brought up by the apparatus of research work.

In the course of scientific research much of the mythical results of poetical imagination, or of mere guesswork, has had to be abandoned; but if in the course of such research we have lost the mermaid and the giant devil fish, the submarine forests and their fearful inhabitants, Davy Jones's locker and King Neptune's submarine palace, we have gained greater wonders and greater beauties.

Our island home is situated in comparatively shallow water, part of the continental shelf formed by the gradual erosion of the land brought about by the constant beating of the waves on rock and cliff and shore, and partly by the mud and other solid matter brought down by the rivers. This area of comparatively shallow water is at its widest in regions like the North Sea, where the gradual subsidence of the land has been accompanied by deposits from the great rivers running into it.

From the outer edge of this shelf starts the continental slope, which is generally understood as stretching down to about 1,000 fathoms. Beyond this depth the slope is very gradual and almost imperceptible, but it continues away into abyssal regions—depths so great that the highest mountain in the world could be accommodated with a mile or more to spare.

Light fades away rapidly in sea-water, especially in the northern seas, and below 500 fathoms there



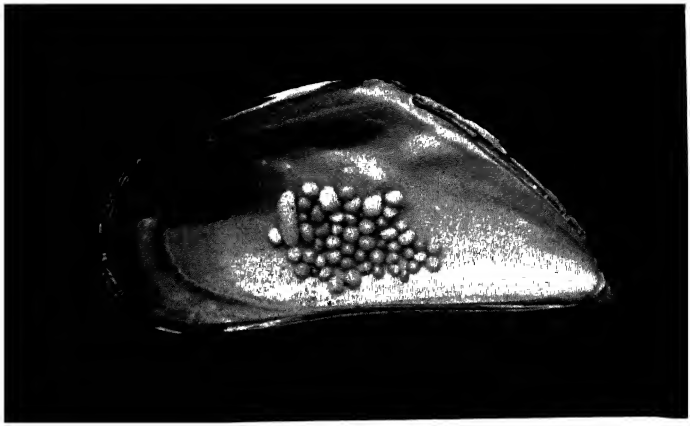
Section of Continental Shelf and Slope off County Donegal, Ireland. Further out in the Atlantic are abyssal depths two and three times greater than shown above

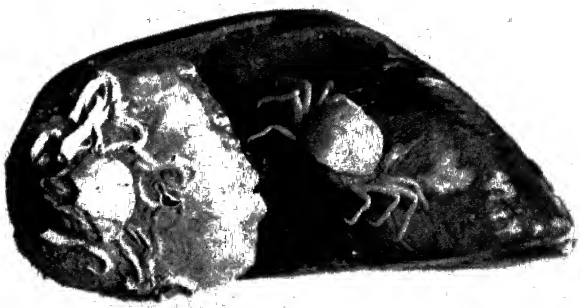
is perpetual darkness. Before that depth is reached, however, the last of the growing weeds and vegetation will have been passed, for these cannot exist without light, and indeed it is doubtful if there is enough light below 100 fathoms to affect growing vegetation; and so the sea floor from there is barren. To destroy long-cherished illusions is always a thankless task, but the submarine forests and verdure-clad hills and valleys must go. Even the fabled Sargasso Sea, to which hundreds of great ships were lured and there entangled and held to their doom in the spreading branches of giant weeds, their crews meanwhile starving to death and terrified by the sight of weird monsters moving in and out amongst the vegetation—even that must be abandoned.

In that fascinating book *An Arcturus Adventure* the author and explorer, William Beebe, tells how he sailed his ship through and through that dreaded area, but although they saw occasional patches of floating weed, none was larger than a man's hand, and much that was examined appeared to be of land origin; whilst the only wrecks he saw were "dissolute Welsh colliers, wallowing past on their unpainted way." Columbus, too, saw those patches of floating weed and recognised them, with renewed hope, as having come from land that could not then be far away.

A barren wilderness in almost total darkness—almost, but not quite—for many of the deep-water

PLATE XV





A COLLECTION OF SMALL PEARLS FOUND IN FRESH-WATER MUSSELS (*See page* 101)

A MUSSEL AND HER PEA-CRAB LODGER WHO LIVES INSIDE THE SHELL BUT CAME OUT TO BE PHOTOGRAPHED (*See page* 102)

animals make their own lights and many others are luminescent in a strange, cold way. On one occasion when trawling at a depth of 300 fathoms some fish were taken covered with this luminescent slime, and my friend in recalling the incident said that he was able to read the clock in the dark wheel-house by the glow from the slime on his hands after handling these fish.

Some of the crustaceans have rows of little lamps along their bodies for some purpose we cannot explain—it may be for protection or to enable the species to recognise its kind, or it may be to enable the animals the better to secure their food—we do not know, nor do we know how these lights, which owe nothing to the sun, are produced. But such minute amounts of illumination cannot affect the perpetual darkness of those realms any more than the glow-worms can light up a country lane at night (see Plate XVI).

Down, down to perpetual quiet and absolute stillness, no sound or movement, for there are no currents in those deeps. Intensely cold too, the temperature being always at or around zero.

The pressure of the water increases rapidly until at 2,000 fathoms it is greater than the pressure on the pistons of our strongest locomotives. Many of the animals are too frail to crush, sponge-like in texture, so that the water pressure is equalised inside and out. When, on the *Challenger*, our earlier explorers endeavoured to obtain records of

temperatures at great depths they were foiled by this intense pressure, for their strongest thermometers were crushed to powder when lowered. Even when wrapped in thick felt and enclosed in strong copper tubing the glass was found, on recovery, to be reduced to powder by the implosion of the copper covering. It was soon discovered, however, that a glass tube, open at both ends and with holes drilled along its sides, could withstand the journey safely. That is how the animals can sustain the load (that is how we sustain the load of the atmosphere), by having the pressure evenly distributed over every fibre of their bodies.

One occasionally still sees paragraphs and letters in newspapers and periodicals discussing the fate of, say, a great ship that is sunk. Does it ever reach the bottom, or does it reach a state of equilibrium in which the pressure from above is equalised by the pressure from below? But it is not pressure, nor bulk, nor weight, that rules such a case. Water is only slightly compressible, and density is the governing factor—*i.e.*, anything that is denser than water will eventually reach the bottom.

The ooze on the bottom is of the consistency of soft butter or, as a cable engineer put it to me, golden syrup, and the progression of the animals must be a combination of swimming and walking on stilts. The sessile animals, such as the sea lilies, anchor their bodies deep in the ooze and send their stems high out into the water above.

There is no corruption, however, at these depths, for there is no bacteriological action, and without bacteria there is no rotting. A dead whale will sink slowly down, nibbled at all the way by thousands of animals, great and small, until nothing is left, for even the bones will be dissolved by the great pressure—all but the ear-bones, which seem to defy it. The ear-bones of certain whales and the teeth of sharks are almost the only solid objects that have been found in abyssal regions, and how long they endure can only be conjectured. The *Challenger* secured nodules of deposited manganese as large as potatoes, and the nucleii of these were sharks' teeth.

The shapes of some of the fishes are almost too strange to be credible. Some, like the sea-devils, are all mouth and tail, the mouth furnished with great teeth which glow with luminescence.

Some have stalk eyes, some of them actually telescopic, and one wonders if these are the optimists in that realm of gloom. Some carry torches and some are able to illuminate the water around them by an emission of light, the counterpart of the squid's smoke-screen.

And what of the sea floor itself; of what is it composed? Sounding in shallow water is done with a line and a lead having tallow in a cavity on its underside. The line is marked in fathoms, and the tallow on the lead will bring up a sample of the bottom it touches. In deep water, however, that

method is quite useless, and piano wire is employed with an iron weight which will automatically fall off when it touches bottom; at the same time the machine will register the depth reached. It is necessary that the weight be released, for it would be impossible to wind it back owing to the great strain. So much of this deep sounding has been done that one might think the bottom of the sea was thickly peppered with these weights. Recent calculations, however, revealed that the average is about one such weight for every 10,000 square miles of ocean!

In conjunction with the sounding weight there is a pair of snappers which, when the weight is released, close upon and secure a sample of the ooze and that will reveal its composition and origin.

Many thousands of square miles of the sea floor are covered deep in deposits of mud brought down by the rivers, etc., as already described; but in the open sea great areas consist of deposits of the empty shells of minute animals that were born, lived and died near the surface. Many of these creatures have perfectly formed shells of exquisite design and are yet no larger than grains of sand. The constant falling of these minute shells forms the dust of the sea, and their numbers are beyond computation; down, down, through those miles of water, down to the sea floor to be added to the countless myriads that preceded them. It has been calculated that the deposits increase in depth at

the rate of about one inch every ten years; and that was how the chalk cliffs of Dover were formed millions of years ago.

Other great areas are formed of the flinty skeletons and shells of different types of animals such as the pterapods, the sea snails, sea butterflies, etc. The latter are small snail-like animals with the foot, as it is called, extended into a pair of flappers not unlike wings; but it would be less inaccurate to call them sea moths, for it is only at night that they come near the surface. In the day-time their wings are folded and the animals sink down into the dimness that they prefer. Some of the pterapods are extremely beautiful (see Plate XVI.) and although their shells are perfectly formed and coated over with a lustre like fine mother-of-pearl, they are so small that you could place more than 300 on the space of your little finger nail.

Such, then, in brief is the sea floor—a realm of perpetual darkness, perfect stillness and perfect silence, intense cold and intense pressure, peopled by creatures who have adapted themselves to these circumstances, an immense wilderness barren of vegetation and almost completely undisturbed by man.

Fishery Research

Deep sounding, however, has little immediate relation to industrial or social life, and while there can be no rigid line drawn between it and fishery

research because the former must necessarily have some concern with the lives of our food fishes, it is rather in the nature of pure than of applied science.

Fishery research is a direct attack upon the problems connected with those forms of underwater life which make up the sea's contribution to the nation's supply of food, as well as of those minor, yet important, products of the sea which are utilised by many and varied industries.

If scientific research is to be made profitable to the fishing industry it must be able to elucidate the problems connected with the life-histories, growth, migrations and distributions of the animals concerned.

It has to be confessed, however, that the acquisition of scientific knowledge in that direction has far outstripped its practical application, and while many years' close study and vigorous research have produced a great volume of most valuable information, its practical results on our sea fisheries are yet to seek.

Some day, inevitably, the key will be found which will open the way for the utilisation of the knowledge already gained and daily being added to, and then we shall reap the benefits of the many years of, at present apparently valueless, labour.

If, for instance, the movements of the herring shoals could be predicted with any certainty, if it

could be established that the coming season would yield a good harvest or otherwise, the industry could be organised and managed accordingly, instead of, as at present, having to rely on blind chance.

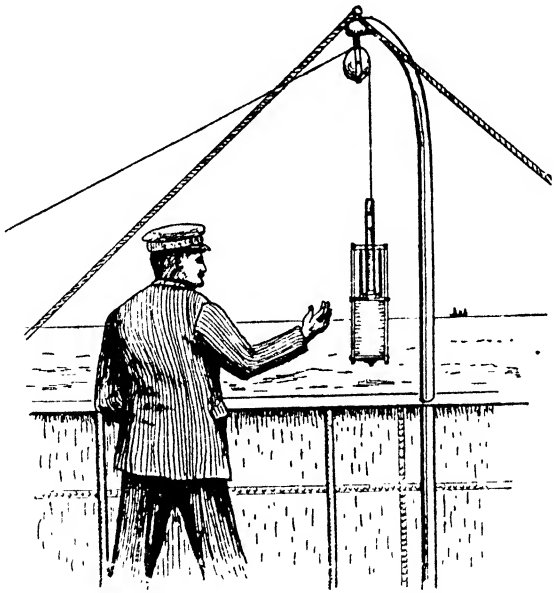
The present position is not quite without its positive advantages, for the knowledge already gained is such as to prevent the passage of useless fishery legislation. The Three-Mile-Limit Act was passed to protect the spawning beds, as it was then believed that most of the food fishes spawn close inshore. It is now known that such is not the case, and that Act is only valuable in so far as it protects the young fish on the nurseries—a useful and valuable thing, but not at all what was intended.

I had the privilege of making a short trip on one of the Ministry of Fisheries research vessels and, through the courtesy of the officials as well as the crew, was able to see some of the work at close quarters and to obtain first-hand information about other aspects of it, as well as many valuable specimens and illustrations.

The gear used on such a vessel can be divided into two main groups—*i.e.*, that used when the vessel is stationary or at anchor, and that employed when moving over the sea. I will describe, as simply as I can, some of the gear, its uses and results, in the following pages.

Deep Sea Water Bottles

It is of the utmost importance that the presence and the movements of "foreign" waters in the North Sea should be ascertained, because it is considered that they have vital bearing on the



Deep Sea Water Bottle coming up with Sample of Water and Temperature

supply of plankton which forms the basis of the food of all young fishes, and correspondingly on their movements and migrations.

These tongues of Arctic water enter from the northern as well as from the southern end of the

GLOBIGERINA OOZE (magnified 10 diameters)
A LUMINOUS CRUSTACEAN (life size)
A CRUSTACEAN IN THE TEST OF A SALP (life size)

Channel, and as they do not mix readily or quickly with the normal North Sea water, they can be traced by taking samples and studying their composition and temperature. So important is this branch of research work that it is considered the only means of charting the incursion of such foreign waters into the North Sea.

The form of bottle used is shown on p. 124, and the figure of the officer has been introduced to give some idea of the size of the bottle.

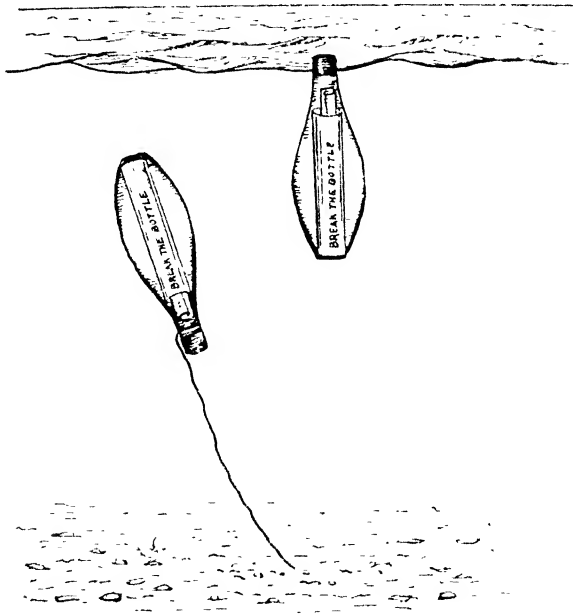
The illustration shows the bottle coming up closed and with a sample of the water and its temperature; these samples are not dealt with on the ship, but are sent to the laboratory for examination and recording.

The bottle, open top and bottom, is lowered on a wire to prearranged depth, and as the wire runs off the machine its progress is recorded until the desired depth is reached. A metal "messenger" is then sent down the wire to close the bottle, and by that means its contents are thoroughly insulated from any intrusion of other waters on the way up as well as from changes of temperature.

Bottom and Surface Drift Bottles

These are of two kinds: surface drifters and bottom drifters. The surface drifter is just sufficiently weighted to float without showing anything above the surface that might be acted on by the wind. The bottom drifter is similar, but has a wire "tail,"

which is just heavy enough to sink the bottle, which drifts along the bottom with the tail just touching. These bottom drifters are intended to be caught in the trawl nets. Inside each bottle is a postcard, on one side of which is a label with the words



Bottom and Surface Drift Bottles

" Break this bottle " in red letters. On the other side of the postcard is a series of questions, in several languages, relating to place of finding, date, etc., and a request that these should be answered and the card posted back to the Ministry of Fisheries.

About 50 per cent. of the bottles put over are recovered, and by their means in the spawning season it is possible to get a good idea of the direction and extent of the drifting of the eggs and newly hatched fish.

The use of these bottles has led to some amusing incidents. Previously cocoa-nuts were used, a hole being bored in them to let in the water and cause them to sink, and a brass label was affixed outside. In the interests of economy the Fishery Department ordered from the local Co-operative Society ½ ton of rotten cocoa-nuts. This order was returned with an indignant letter to the effect that the society never supplied any unsound goods! However, when the society was convinced that the order was really genuine the cocoa-nuts were forthcoming, and at the next annual meeting a speaker made the point that the society could supply anything, even to ½ ton of rotten cocoa-nuts.

In the early days of the war a man found one of the bottles cast up on the beach; he carefully covered it with sand and then reported to the naval authorities that he had found a German mine. It is not recorded what the naval people said!

On another occasion a Dutchman found one bottle and then another until he had amassed thirteen. Judging from his letter in comical English, doubtless written by the local big-wig, he thought he was entitled to a small fortune.

Before the war a German girl spending a holiday

on the island of Borkum found one of these bottles; in sending back the card she asked that, instead of the shilling reward, might she have some picture postcards of London. She got these, you may be sure, *and* the reward—trust our young officers for that!

Remarkable instances of distances covered by these bottles are also recorded, some cards having been returned from over 1,000 miles away from the point where they were put overboard.

Current Meter

In addition to the evidence furnished by the bottom and surface drift bottles, the strength and direction of currents can be measured directly by means of specially designed meters; this is especially valuable in the case of deep-water currents, as these frequently differ from the surface movements.

One of the most ingenious of this type of instrument is the Eckmann current meter, which is used from an anchored vessel. When lowered to the desired depth the vanes of the meter set in the direction of the current in a similar manner to those of a wind vane, and the force of the current turns a small propeller which works a counter and indicates how many turns it has made in any given period, and consequently the speed of the current. In connection with the vanes there is a box with compartments representing the points of the compass, and a large magnetic needle having a groove along its

upper side. As the propeller turns, the mechanism deposits small bronze shot into the groove of the needle, and these roll along and drop off the point—which, of course, is always due north—into one of the compartments underneath.

If the meter were merely hauled back without some such arrangement it would not indicate the direction in which it had been setting, because it would probably change many times on the way up. By ascertaining which compartment has the largest number of shot, however, the direction of the current is at once indicated.

The Grab

Investigation into the distribution of the animals living on the bottom is an important branch of fishery research, as all these animals form the food of certain fish, and these fish are only found in any substantial numbers where their favourite food is plentiful.

In turn each kind of invertebrate has its own particular liking in feeding grounds; the worms, for instance, prefer mud, whilst other animals prefer sand, or sand and shell, or gravel, etc.

Therefore, if the nature of the bottom is known, the type of fish likely to be taken there is clearly indicated; soles prefer worms as food, and consequently are chiefly taken on muddy ground.

The instruments employed in this branch of the work include grabs, dredges, and shrimp trawls.

The former two are very similar to those used for harbour dredging, and their essential features are the same. The grab, for instance, is a small model of the ordinary type; it covers an area of $\frac{1}{8}$ square metre and digs in several inches. By the use of the grab it is possible to estimate the amount of bottom food available on any particular area, and this knowledge is valuable in view of the suggested transplantation of small fish, such as plaice, from the shallow-water nurseries, which are usually overcrowded, to the richer feeding grounds that are known to exist in such areas as the Dogger Bank.

It has been proved that bottom-living animals rely as much on certain types of bottom as do certain plants on particular soils, and that if the young animals settle on unsuitable ground they perish.

Abnormal winds during the breeding season of some of these invertebrates may cause a drift which will carry the young on to unsuitable ground, and so be the cause of good and bad years for that particular animal.

But the sea pastures, like those of the land, are subject to the invasion of undesirable growths, which may get the upper hand and destroy the legitimate crop. Definite instances of this are revealed by the grab. On one occasion a large patch of ground was examined, and it was found that 75 per cent. of the shell-fish, which were valuable fish-food, had been killed in their first year by the sea snail Natica, which bores a hole in the shell and

sucks out its victim. It is thought that this boring is done by the radula of the snail, with the assistance of an acid secretion, while the shells lie buried in the sand.

Specimens of Natica were also found empty, with their shells bored by their own kind, and probably the balance of nature becomes restored by the invaders being obliged to subsist upon their fellows when the supply of natives becomes inadequate. In the sea crops man can do nothing to eradicate the tares.

A triangular iron dredge is used when the ship is moving, and frequent hauling of the dredge indicates the nature of the bottom, and is a preparation for the closer examination of selected areas by the grab.

Plankton

Under this heading comes all the plant and animal life that drifts passively with the current: the single plant cells (diatoms), pterapods, copepods, fishes' eggs and embryos, the larvæ of molluscs, crustaceans, etc., all the ingredients of the "sea-soup" which ultimately nourishes the whole animal kingdom of the sea.

Not alone an army, but every living creature marches on its stomach, and the supply of food is the greatest of all problems for us all—from man down to the humblest coral polyp.

All animals require organic substances for food —*i.e.*, substances which already form the bodies of

plants or animals—but plants can build up their bodies from inorganic substances; all they require is moisture from the sea or the soil, with a trace of dissolved salts, carbon dioxide from the air, and energy from the sun.

On land, except where it is too hot or too dry, there is enough vegetation to support half the animal population, from, say, green flies up to cattle and horses; the remainder eat these vegetarians. In the sea, however, there is no growing vegetation apart from the coastal fringe of sea-weed, and the problem of supplying its mighty hosts with sustenance takes on another character altogether. It is no more possible for animals to subsist by eating each other than it was for the inhabitants of that legendary town who proposed to live by taking in each other's washing.

It is through the microscope we must look, at material secured by the plankton nets, for the solution of the problem of feeding those multitudes in the sea "that no man can number."

Several types of nets are used, but the material of the nets is generally bolting silk, although some of the organisms are too small to be retained by the finest silk net, and can only be obtained with the water they are in, which is preserved and afterwards centrifuged. Tow-nets are simply conical bags of silk, their mouths kept open by a metal ring, and this type is used for rough sampling, being towed behind the ship at various depths. The Nansen net

is an improved form of tow-net, because it can be sent down to fish at a particular depth for a stated time, and it can be closed by a throttling band worked by a metal messenger sent down the towing line. The Hensen net is used for vertical sampling and for quantitative work, such as the estimate of the numbers of fishes' eggs in the plankton; the mouth of the net is a standard size, so that, allowing for filtration, it is possible to work out the number of organisms per square metre of surface.

It is in this way that the spawning grounds of the plaice and the cod were ascertained and charted. The catches of the net are preserved in weak formalin, and afterwards sorted and identified in the laboratory, the presence of the fishes' eggs in certain numbers at certain stations enabling the investigators to mark out definitely where the spawning takes place. As both cod and plaice spawn in the winter months, this kind of fishery research is often far from pleasant.

But to return to the food question. Either directly or indirectly diatoms form the food of all life in the sea. While adult fish seldom feed on these plant cells, the newly hatched fish sometimes do so; but the copepods, which form the staple food of most young fish, feed almost entirely upon diatoms.

Every drop of water taken at or near the surface is crowded with these minute plants, which multiply by simple division, each growing and then dividing

into separate organisms at a very fast rate. In countless millions they swarm and propagate; in countless shapes, from simple silica envelopes containing the germ of life to complicated honeycomb and gridiron patterns. An American professor states that over 8,000 different species have been identified, and some of them so small that 200 would hardly cover a pin's head. The rate at which these minute plants multiply is so great that in the English Channel off Plymouth the animal yield of diatoms in the water layers beneath 1 acre of surface has been calculated to amount to over 5 tons.

Countless myriads of minute animals find in these microscopic plants their food supply, digesting the plant body and utilising the energy thus set free for their own lives. On these small animals larger forms prey, and so the chain of life may consist of many links spreading downward into abyssal regions from the surface. The copepod eats the diatom, the fry the copepod, the sprat the fry, the herring the sprat, the salmon the herring, and the shark the salmon. In turn the shark dies and sinks down, attacked and eaten by countless animals great and small that he despised in life. It is the ceaseless rain of such living and dead matter on to the bottom that sustains all the countless forms of life there, and it all owes its existence to the sun, which at the great depths might be deemed to be as ineffective as the farthest star.

The abundance of this minute life in the sea

baffles the imagination. A single cupful of water may contain many thousands of plants and animals, and only their astonishing power of propagation prevents their wholesale destruction by the hosts that prey upon them.

The old whale's mouthful (in *Water Babies*) of 943 sea-moths, 13,846 jelly-fish, and 43 little ice-crabs was no whit exaggerated, for the quantities which that whalebone-sieve can separate from the water are beyond calculation except by weight or cubic measure.

The migration of some kinds of fish is influenced by the condition of the plankton at certain times, and that in turn is governed by the presence or absence of sufficient sun. The amount of sunshine in the spring may affect the supply of mackerel in the autumn, and so on. Certain types of diatom are supposed to be avoided by the herring because the sharp points of the silica skeletons set up irritation in the fishes' gills, and as these types occasionally occur so thickly as to choke the tow-nets, there may be ground for the belief, but there does not seem to be definite proof that movements of the herring shoals are thereby affected.

The copepods which feed upon the diatoms are of great importance as the food of almost all young and some adult fish, and also of many animals upon which the fish feed. The arrow worm, which is found in considerable numbers in the plankton, is an enemy of the young fish, but itself serves as

food for fishes that have passed their post-larval stage.

And so the links in the chains of marine life take many forms, but all have their beginning on or near the surface in these wonderful plant cells.

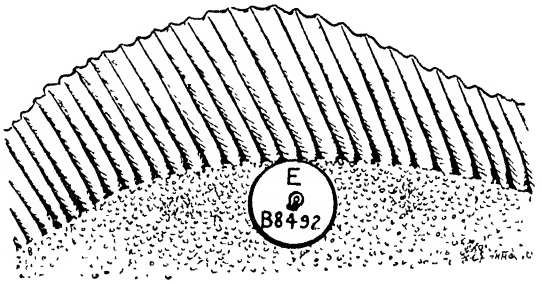
Marking Live Fish

The marking of living fish taken in the nets and the returning of them to their native haunts again are done in order to obtain information about their seasonal migrations, their rate of growth, and the results of the intensive fishing which goes on steadily in home waters. With regard to the results of the intensive trawling it is established that if 25 per cent. of the marked fish are accounted for within twelve months, then at least the same percentage of unmarked fish of the same range in size will be caught on that particular ground in a year.

It is due to actual marking experiments that the phenomenal growth of plaice transported from the shallow-water nurseries to the rich feeding grounds of the Dogger Bank has been established, and examination of the bottom, as just explained, has shown that the reason for the Dogger Bank being such a good growing ground for plaice is the existence there in large numbers of certain shell-fish on which the plaice feed. One would suppose that seeing there is such good feeding on these grounds the plaice would find their way there naturally, but the young fish seem unable to cross the deep water

that separates the Dogger Bank from their nurseries; they seem to be able to negotiate depths only in proportion to their size, the younger fish preferring the shallower water.

The problem therefore resolves itself into the practicability of transferring large numbers of young fish from the nurseries over the deep-water barrier to richer feeding grounds. The Continental coast is crowded with immature fish which would grow



Fish Mark, attached to a Plaice

quickly to marketable size with better feeding; the good pastures are there, and not overcrowded, if the transplantation were feasible.

Unfortunately, there are no funds available for a large-scale experiment, and, very naturally, the fishing industry does not feel disposed to bear the cost, so nothing is done to reap the fruits of this piece of fishery research.

Marking of living fish is done by fastening numbered discs to the fish with silver wire passed through the thick base of the fins. The discs or

labels are now made of vulcanite, but formerly they were made of bone and brass. The discs show the number and the country of origin, and as most of the countries bordering on the North Sea are carrying on this work, each receives reports from the others of marked fish landed at their respective ports.

When the fish are taken in the trawl they are quickly transferred to tanks on deck; each fish is measured when marked, and the particulars of date, position of ship, length of fish, etc., carefully noted against the entry of its disc number.

A reward of 2s., plus the value of the fish, is paid for each one returned with particulars of position and time of capture. The journeys made in a year by marked plaice are not generally more than 100 miles, though one marked in the North Sea was retaken near the Eddystone, but striking variations in the rate of growth result from the examination of such recaptured specimens. Each fish when recaptured is again measured and its age ascertained, from the otoliths in the case of plaice, and from their scales in cod and other types.

Most of the food fishes have been marked in this way, but it has not been found practicable in the case of the herring. On one occasion a large number of herring were marked, but when they were being put over again a shoal of tunny came round and snapped them all up! This happened some 70 miles or so off Flamborough Head.

Odds and Ends

When the net is hauled, after dragging along the bottom for some hours, it contains, in addition to fish, a very varied collection of bottom-living animals, from the lowly worms to the highly complicated forms of molluscs and crustaceans. This is specially the case when small-mesh nets are used, and the examination of this debris is of great interest to the naturalist, though the fisherman may think it sheer waste of time, or worse.

The worms are a very large class, and of very considerable importance as the food supply of many commercially valuable food fishes. The most direct method of finding what certain fish feed upon is to examine their stomachs, and where the constant presence of, say, worms proves that to be the staple diet of the soles, for example, it follows that the best fishing ground for soles will be where worms abound.

Cod are not particular in their feeding, however, and will swallow many odd things ; on one occasion a boot was found in a cod's stomach, and when I mentioned this when lecturing at a well-known public school the headmaster (who shall be nameless here) went one better by telling the audience that a Bible had been so found ! Whole crabs are often swallowed, even the northern stone crab, which has a very rugged carapace that might have been supposed to protect it against such indignity.

The sea-mouse (Plate III) belongs to the worm family, and is one of the most attractive of the species. The fisherman's lug-worm, whose castings are so common on sandy shores, is most attractively coloured when one overcomes the natural repugnance which its long sinuous shape generally creates. Like the common earth-worm the lug-worm spends its time in swallowing the sand in which it lives, extracting nutriment from it and then passing it out in the form of the familiar casts. The lug-worm is the marine counterpart of the land lob-worm, and equally common, but the origin of their names does not seem to have been established. To the zoologist the lug-worm is a beautiful creature, its iridescent colouring of bristles, gill tufts, and delicate barbules having earned it the extra title of " rainbow worm." It possesses the property, common in the lowly forms of life, of being able to abandon portions of its body in time of need, and such portions are able to reform themselves into complete wholes again by the regeneration of missing head or tail.

The lancelet is another favourite item of food for cod, and it is a stepping stone between the invertebrates and the vertebrates. It has no brain, no eyes, and no real heart; but having a notochord, as in larval fishes, the lancelet is placed above the worms. The lancelet is very agile, and can bury itself in the sand as rapidly as a sand-eel.

The so-called ship-worm (teredo) is not a worm at all, but a bivalve with a pair of shells with which

it bores out its home in wood or other solid substances. These shells look ridiculously small for the animal, and only cover its head and vital organs. By a combined use of its foot and the shells the teredo drills along the soft grain of the wood, steadily enlarging its home to suit its own growth, and never leaving it. In its early stages the shipworm is a free-swimming organism which seems to be irresistibly attracted to submerged wood. Wood exposed to the air becomes a prey to terrestrial animals, and wood submerged in the sea is subject to invasion by marine forms of which teredo is by far the most formidable.

Boring into a submerged pile or bridge support, these animals turn in the direction of the grain, never enlarging the original entrance, but riddling the whole without leaving the slightest external indications of their ravages. The burrows they make do not seem to mingle, and the animals apparently change direction when they get too close together, and so avoid breaking into each other's homes. Immense damage has been done by their ravages, and before the era of iron ships many a gallant vessel went to its doom quite unexpectedly and without the least warning because the timbers had been ruined so completely that total collapse was unavoidable. A great many devices have been tried in order to protect submerged wood-work, but none has ever proved really successful; many patents have been taken out to defeat this wrecker,

and while iron ships are immune from its attacks, there is still much wood used in dock-work, etc., which is open to attack. Early in the eighteenth century large portions of the coast of Holland were threatened with annihilation, because the piles which supported the dykes and walls were attacked by a species of teredo, and very large sums of money were expended in fighting this formidable foe.

Fortunately, the animal has its dislikes, and iron rust is one of these, so that timber can be protected to some extent by suitable treatment. One simple method is that of studding the wood closely with iron nails, the rust from which spreads rapidly over the surface. Very hard woods, such as green-heart, resist attack to a large extent, and are now generally used for that reason.

The piddock (pholas) is another boring bivalve, but it prefers chalk or other hard substance, even soft rocks, for its home. Consequently the rock-borers do far less harm than the teredo type, and present a comparatively minor problem of defence. The piddocks work slowly and seldom attack cement or concrete, though there are recorded cases of considerable damage being caused to canal and dock-work through the weakening of the structure by the borers. An interesting feature in the piddock is that it is one of the most luminescent of marine creatures, and glows with a powerful greenish blue light which does not emanate from any definite light organs, but is produced all over the skin of

the animal. The piddock also remains in the hole it first makes, never enlarging the entrance, but drawing in supplies of food and oxygen by means of its syphons, which can be extended to the entrance, and withdrawn when not so required.

In strong contrast to these solitary creatures are the colonising animals, such as the corals, the sea-mats, hydroids, etc.

Coral is found in our seas only in deep water and in small quantities, but as builders of the sea there is nothing to equal the coral polyps, and their influence on the human race has been tremendous. The great coral barriers have conquered the seas in many regions, and are permanent engineering feats of unequalled importance and value—the Florida reef; those of Bahama, Bermuda, and the South Sea Islands; greatest of all that of Australia, which extends for a thousand miles.

In the case of the coral polyp instinct would seem almost to border on reason, and the beauty of form of some of their structures is very striking.

In living coral the outside covering is a living bark, the inside is dead. The bodies of these minute creatures are shaped somewhat like sacks, the open end provided with fairy-like tentacles for procuring food. In life their soft bodies are joined into a living mass, in death only the hard skeleton remains; the polyps build on the tombs of their ancestors.

A common object on the shore and in the nets is the sea-mat or horn-wrack (flustra), which most

of us would take for a piece of sea-weed, but is in reality a colony of living animals known as polyzoa. The tuber-like base closely resembles a plant, and the spreading leaf-like growth adds to the confusion. The colony is about 4 inches in height, and the fronds spread over sea-weed, rocks, etc. If a portion of one of the fronds is magnified it will be seen to consist of a regular formation of small cavities, each of which is the home of a minute polyp; in appearance somewhat like a fresh-water hydra, though actually related to the worms.

The shells of scallops, oysters and other molluscs are frequently found with delicate growths of hydroids that resemble fine branching grasses. These colonies of living animals are very intricate and have a complicated life history, which is surprising in such lowly creatures. The breeding polyps are produced like budding blossoms, but float away in the form of minute jelly-fish, some of them very beautifully marked, but furnished with deadly trailing tentacles with which they secure their food. These medusæ produce eggs which, sinking on to some solid object, become attached and start new colonies of hydroids. A plank from an old hulk will provide material of that sort for endless study and wonder.

The sea-anemones are best studied in a clear rocky pool, where their delicate colouring is shown to full advantage. What is the object of these beautiful flower-like shades of colour? Is it to

attract small worms and other marine animals, just as flowers attract bees and other insects? In the case of the sea-anemone the delicate frond-like tentacles surround the creature's mouth and collect the necessary food. The tentacles are hollow and furnished with poisoned darts which paralyse or kill unwary or unfortunate creatures that come within reach, and then close over the prey.

Some time ago I was watching some beautiful specimens in the aquarium at the Zoological Society's Gardens in Regent's Park, and had an excellent opportunity of studying their movements when in search of prey. The delicate tentacles were waving ceaselessly in the water, in which were swimming a number of shrimps, and one of these happened to touch with the point of his long feelers one of the waving tentacles. Immediately the shrimp jerked itself backwards and seemed to shiver at the shock, ultimately settling down very gingerly on the sand well clear of its enemy. The anemone closed up suddenly to grasp its prey, but was just too late.

The anemones are capable of a certain amount of movement of their own, but some of them enter into partnership with crabs and other roving animals, and so get carried about, sharing food and assisting to obtain it. Frequently the quaint hermit crab has an anemone on its shell, and one must suppose that the arrangement is mutually profitable. The anemone disguises the crab, and in turn gets

some of the crumbs which fall from the crab's table.

In the large family of the echinoderms are included also the sea-cucumbers, sea-gherkins, sea-urchins and many others. The sea-cucumber is the "trepang" or "bêche-de-mer" of southern seas, and is secured, dried and shipped to China in considerable quantities for human consumption, being considered a great delicacy by the Chinese. Those that are obtained in home waters are colourless and uninteresting in appearance, clumsy in shape, and with the usual tentacle-fringed mouth. These tentacles are covered with slime, and particles of food quickly collect upon them; they are then curved inwards into the animal's mouth and slowly withdrawn, the food being scraped off in the process or sucked clean as a child will suck jam off its fingers. This animal has one unique accomplishment in that when in serious trouble it can get rid of its whole viscera and grow a new set—a somewhat drastic if complete cure for indigestion.

The sea-urchins are the hedgehogs of the marine world, for they are covered with stiff sharp bristles. Normal movement is by means of small tube feet, but the urchin has five strong and somewhat complicated teeth which can in emergency assist its locomotion, for when really in a hurry the urchin can run along on the tips of its teeth. Although the urchin appears to be well protected by its bristles, it often falls a victim to the star-fish. The star places

a limb on the urchin, and a number of bristles penetrate the limb, which is then quickly withdrawn with the offending bristles adhering to it, for they are easily detached. This process is repeated until all the bristles are removed, when the star will wrap its protrusible stomach round the urchin if the latter is too large to be accommodated in the more usual way.

Allowing one type of animal to lead us on to another, the star-fish (which are not fish) may be next mentioned. The common five-finger is nowhere looked upon with favour, and can be very destructive on oyster and mussel beds, where it devours large quantities of the valuable molluscs. Although the star-fish cannot be credited with possessing a brain, it is wonderfully efficient in its own sphere. The under-sides of the five limbs are furnished with tube feet worked by water pressure from inside, and by means of these the animal can move about freely ; with their aid, too, it can compel mussels and oysters to open their valves and so expose their bodies to destruction. The star hunches its body over the bivalve, and gripping both shells with its tube feet, continues relentlessly to pull the shells apart until they begin to gape ; for though the closing muscles of the bivalve are stronger than the tube feet, they tire much more quickly.

Each of the tube feet, and there are two rows on each limb, terminates in a small sucker, which is

connected with a complicated system of water channels, and by means of water pressure the sucker can be forced out or withdrawn at will, enabling the animal in turn to take hold or relax it.

The star-fish exhibits the faculty of regrowing lost parts in a remarkable manner, and it is common to find a star with one or more limbs shorter than the others—not yet fully grown. The brittle star got its name from its apparent readiness to part with its limbs; if you hold a brittle star by one limb it will let you keep that quite readily, and you can repeat the process until you have all five limbs and only the centre of the animal is left intact. This centre, however, will quickly proceed to grow a new set of limbs equal in all respects to the original ones. This would seem to be a very literal obedience to the instruction that "if thy hand offend thee, cast it from thee."

Another very common object on the sea floor and common on many beaches is the whelk, which is a large sea-snail. The masses of empty capsules, often two or three times larger than the parent whelk, are found on most beaches, and are evidence of what at first sight looks like great natural waste, for each capsule will have contained some dozens of eggs, and such a huge supply is surely not necessary for the continuation of the race.

Each young whelk, however, starts life as a cannibal, for in each capsule there are many more eggs than could possibly find room to develop if

they all hatched out; and so those that hatch out earliest turn on the slower ones and eat them, the quicker eating the slower, the stronger the weaker, until only a few are left to emerge from the capsule. This version of nature's providing for the masses and not for the individual is frequently rounded off by the statement that the process of elimination goes on steadily until only one whelk is left in each capsule, but that is not often found to be the case in real life. There are certainly many more individuals in the very early stages than there are later, and there is nothing in the shape of yolk for them to feed upon, so they have no alternative but to subsist upon their own kind until they leave the capsule.

Whelks, which sometimes grow to 4 inches in length, are eaten in substantial quantities, but their flesh is close and tough. The periwinkles, also members of the marine snail family, are the most important commercially of the univalves that are used for food; they are common on rocks and stones between tide-marks, where they are gathered by hand at low tide and (usually) boiled before being eaten.

The whelk is an enemy of the more valuable bivalve, the oyster, which he destroys by cutting a hole clean through the latter's shell and then sucking out the contents. At the end of the whelk's tongue is an array of minute teeth, which are used as a rasp in making the opening.

The common limpet (crepidula) is also collected

and sold as food in many districts, but the flesh is very tough.

An undesirable addition to the limpet family is the slipper limpet, which appears originally to have been imported from America in a consignment of young oysters. The supply of native oysters is quite inadequate, and large quantities of immature ones are imported for relaying in favourable estuaries and creeks where feeding is good and where they can grow comparatively quickly to marketable size.

This unwanted alien has become a pest on the oyster beds round our coasts, although not a pest in its own home waters. It is not really a limpet, and, while it does not directly attack the oysters, it lives on the same food; apparently they find our waters very congenial, and multiplying quickly they deplete the food supply on the oyster beds. The limpets have a curious habit of roosting one upon another until groups of ten or a dozen are formed, and apparently they remain permanently in that position—the sky-scraper habit reaching down to the molluscs! The eggs of the slipper limpet are contained in membranous sacs, which are attached to a piece of rock by the same threads that seem to close the top of the sacs, as if the extra length had been left for that very purpose. The young escape through small holes in the sac, and after the free-swimming period settle down for good on some solid object.

So definite did this menace to the native oysters

become that the Ministry of Fisheries set up a crushing mill at one of the East Coast oyster fisheries with the object of turning the pest into something useful—in this instance into grit for chickens. It was hoped that by thus finding a market for the ground shells the fishermen, who were paid for doing so, would clear them off the oyster beds. This answered satisfactorily for a time, but the supply of shells dropped off, although there seemed to be no diminution of the invasion of the pest on the beds, and the factory was eventually closed.

The occupation of empty whelk shells by hermit crabs is familiar to all who visit the seashore. This curious creature has only a soft unprotected body, with no protecting carapace of its own, and must needs search for a suitable shelter into which to push its defenceless body; whenever possible it chooses the spiral shell of a whelk, holding on to the inside of the shell by means of claw-like appendages at the end of its body. From now on, the hermit shuffles along, dragging his house with him, in a very awkward-seeming manner. He can, however, change from one shell to another, and must do so as he grows in size.

Crabs are harassed by enemies on every hand, and their lives are so hazardous that they are obliged to enter into defensive alliances. One species carries in each front claw a small anemone, and in return for the screening afforded by the latter it shares in the crab's feasts. The anemones, too, by their

stinging darts, can ward off enemies, and so the partnership is mutually profitable.

A sponge and a hermit crab may join forces for mutual protection and profit; the sponge, incapable of moving about after the larval stage, secures a vehicle in the crab, and by its offensive odour and gritty consistency ensures its own safety as well as that of its host.

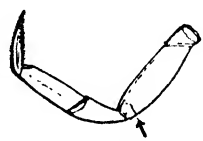
The common shore crab is subject to the unwelcome attentions of a particularly loathsome parasite called sacculina, which is, oddly enough, a distant relative of the crab itself. If it were not that the life history of this parasite has been carefully worked out by scientific research and observation, it would scarcely be credible. In its early stages the sacculina is a free-swimming larva similar to that of the barnacle, and later becomes attached to the soft part of the body of a crab. Its proboscis penetrates the flesh of the crab, and living cells from the parasite actually flow into the host, after which the appendage falls away. The parasite settles down in the centre of the crab's body and sends out roots in all directions through and through its victim until the approach of maturity, when these roots or threads meet outside and form what is aptly termed a sucking-bag. From this bag or sac will ultimately be liberated large numbers of larvæ to carry on the foul work.

Crabs so infected cease to grow, and never again shed their carapaces.

The masked crabs are not so common and are very much smaller than the common shore crabs. They live mostly buried in the sand with just the tips of their long feelers exposed, and when these feelers are brought together the minute bristles fringing the inner edges interlock to form a tube through which the creature sucks in the water it requires for sustenance and oxygen. Their name is a reference to the curious mask-like markings on the carapace, some of them being quite striking in their likeness to a face mask. There is a marked difference between the sexes, the male being much larger than the female and having extra long claws, whereas the female has quite short ones.

Regenerating Lost Parts

The crustaceans exhibit remarkable facility in growing new limbs to replace lost or damaged ones, and, in particular, many crabs are found with an incomplete set of limbs which will be made good at their next moult. It is probable that the crabs exhibit the most highly developed form of what is called autotomy, for their walking limbs are actually provided with a breaking plane where the fracture is always made.



The Breaking Plane in a Crab's Leg

On one of the segments there is a ring completely around the shell covering to facilitate throwing off the injured part.

It is generally considered that this is a provision against the liability of the limbs of the shore crab becoming caught between stones, etc., especially in rough weather.

Immediately after the separation new cells begin to grow over the stump, and in time a complete new limb in miniature is formed. At the next moult this new limb is quickly expanded to normal size, and that would seem to be a remarkable case of adaptation, because the crab would be seriously handicapped in its movements by a gradually growing new limb, and can manage better without the missing one until it is convenient to produce it quickly in the moulting operation.

On a recent visit to the Zoo I was just too late to watch a fight between two large lobsters, but the vanquished had retired disconsolately to a corner to nurse his injury (the complete loss of his crushing claw), and the victor was enjoying a meal by extracting the fleshy part of the claw which he had succeeded in wrenching from his opponent. The losing lobster would be seriously handicapped, however, in the lack of his crushing claw, and would require to wait until the next moult for a new one, although the preparation of that would be begun immediately. Inside the next remaining segment of the limb a model new crushing claw would be gradually formed, and when the old shell was shed in preparation for a new one, this miniature claw would be rapidly expanded to full size with complete shell covering.

Medusæ

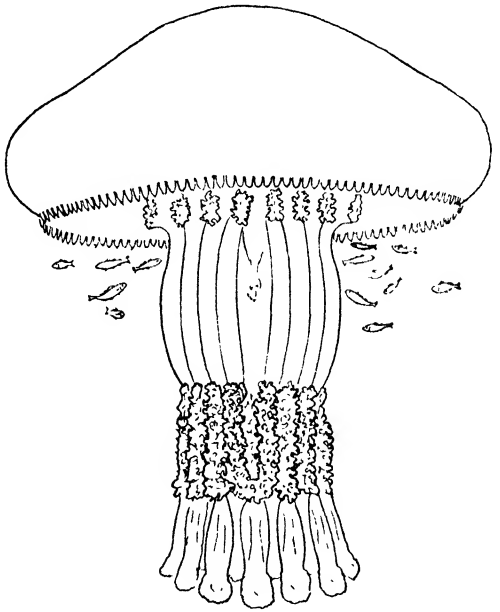
Walking along the sea-shore at low tide, one can often see, lying derelict on the sands, gelatinous, disc-like masses of a bluish-green colour, semi-transparent, and generally repulsive enough in appearance to prevent close scrutiny or handling. If, however, these animals are seen alive floating on the ocean, they are amongst the most graceful of its ornaments. They are characteristically open-sea animals, their presence on the beach being accidental.

Suspended on the waters the medusa resembles a bell, an umbrella, or even more closely a mushroom whose stalk has been separated into tentacles of varied shape and colour, fringed, edged with hair-like appendages which descend vertically into the water. Why was this name, of such sinister associations, bestowed on such a delicate creature?

Of all the animals in the sea, none are more numerous in species or more singular in structure, more odd in their form or more remarkable in their mode of reproduction. They are found in every sea: in the icy waters of Greenland and under the blaze of the equatorial sun, and in the summer months are quite common round our own coasts. They are of all animals those which present the least solid substance; their bodies are little else than water, a transparent jelly, almost without consistence, the solid parts amounting to less than 10 per cent. of

the whole, and yet some jelly-fish are used as food in Japan.

This gelatinous substance is sometimes as colourless as crystal, sometimes opaline, and occasionally pale blue, green, or rose-colour.



Young Whiting sheltering under a large Jelly-Fish

But these fragile beings, which will dissolve on the beach into practically nothing at all, can make long voyages on the sea and survive all its buffetings. Their progress is very slow, and they usually inhabit the deeper seas, moving in considerable

numbers by means of constant expansion and contraction of their bodies. If an obstacle arrests them, if an enemy touches, the movements cease, the umbrella contracts and is diminished in volume, the tentacles are folded up, and the creature descends into the depths of the ocean.

The medusa is furnished with a mouth in the middle of the under-side of the disc, and is a voracious feeder, eating small fish, molluscs, and crustaceans, which are entangled and stung to death by the long lips.

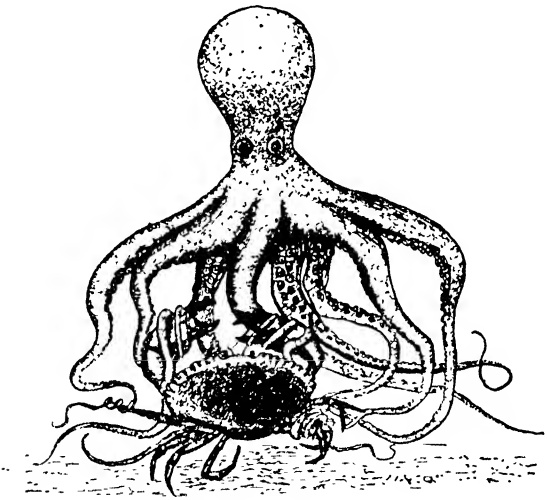
Most of them have poisonous tentacles with which they sting or kill their prey, and they used to be classed as sea-nettles, because even the human skin was susceptible to acute irritation on contact. So virulent is this poison that small fishes are killed instantly on coming into contact with the sinuous, vibrating appendages, and yet it would seem as if the jelly-fish had powers of discrimination, because many small fishes use the umbrella as a shelter from their enemies and appear to occupy it with immunity. It is not possible, however, to make sure that when this is the case there is not also a considerable number of casualties among the lodgers !

The Cuttles

Although usually termed cuttle-*fish*, it is not a fish at all, but a mollusc, and is allied to the slugs, snails, and bivalves, being by far the most highly organised class of mollusca.

There are three varieties known in our seas : the cuttle, the squid, and the octopus.

Unlike most molluscs, they are symmetrical animals, the right and left sides being equally developed ; the shell is internal, and they have powerful jaws, not unlike the mandibles of parrots, which they



An Octopus attacking a Crab

use for tearing up their food and for wrenching the protective carapaces from crabs, lobsters, etc., in order to get at the flesh of their prey.

The head is encircled by eight limbs or arms joined together by skin at their bases, and beneath the arms are two very large and conspicuous eyes. Some of the cuttles are beautifully coloured and have bright spots of vivid colour which are under the

control of the nervous system, so that they can be instantly dilated or contracted at will. Some cuttles are transparent and others adapt their colour quickly to their surroundings.

The inner surface of the limbs is covered by rows of suckers, which have great clinging power. These disc-like suckers are depressed in the middle and can be worked like pistons. When the outer edges are pressed on an object the centre is withdrawn and a vacuum formed. A crab or a lobster has little chance when a cuttle gets hold: the cutting and crushing claws of the crustacean are wrapped round in a strangle-hold, and the animal completely disabled; then the strong sharp jaw or beak does the rest.

The octopus has eight limbs, as its name suggests, but the squids and the cuttles have in addition two long tentacles with spoon-like extremities (one might call them arms and hands); the latter are also furnished with suckers on the under-sides (palms).

Squids and Cuttles

The cuttles are in some parts of the country called "cuddle-fish." There is an etymological basis for this, but its ordinary use would seem to be a sly reference to the long "arms" of the animals!

Below the head is a gland where the ink (the sepia of our colour boxes) is produced, and a reservoir where a quantity is kept ready mixed for use. When danger threatens the cuttle discharges this inky fluid,

which renders the water turgid, at the same time extending its long tentacles, and this action results in a rapid backward movement through the water, similar to that of a destroyer retreating behind a smoke screen of its own making (see frontispiece for illustration).

Large squid require careful handling when caught if one is to escape a drenching of skin and clothes by the inky fluid, which is hard to remove and has a burning effect on the skin. The fishermen gaff the squid when hauled near enough, and hold them, head away, in the water until all the ink is discharged.

The shell of the cuttle is reduced to a supporting "bone" inside the animal. This is the cuttle bone of our bird fanciers, and used also to be greatly in demand for grinding into pounce powder before the era of blotting-paper. The presence of so many of these cuttle bones on our shores is eloquent of the effects of the conger and other large fish in keeping the cuttles within limits of numbers, for the conger has no fear of the cuttle, his slippery skin gives no hold to the suckers of the mollusc, and his sharp teeth make short work of the succulent tentacles.

In the squids the shell is also internal, and is reduced even further than in the cuttles, being only a long, thin, semi-transparent horny "pen." The squids swim in shoals, often near the surface, and feed mostly on fish, which in turn find the squids very palatable, as fishermen know when they use them for bait.

The octopus is common along our southern shores and round the Channel Islands, and is the most familiar to us because of its frequent appearance in the aquarium.

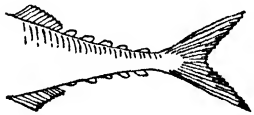
Under any conditions an ugly creature, the octopus seems to consist of a fleshy bag, with large, staring eyes, and limbs which coil and twine about in all directions. It is, however, capable of rapid and graceful swimming, and possesses a large brain and more highly developed eyes than any other invertebrate animal.

The length of the body without arms is seldom more than 6 inches, but the tentacles may be as much as 2 feet long each. These tentacles are, like those of the cuttle, furnished with suckers which give a deadly grip of its victims. Its food consists mainly of crabs and lobsters, and its chief enemy is the conger. Another chain can here be formed: the conger eats the octopus; the octopus the crab; the crab the worm; the worm the debris.

In warmer seas these molluscs grow to a great size and are very seldom seen, although fearsome tales are told about them. In some of the largest whales there were found indigested remains of giant squid, particularly the horrid sharp claws with which the centres of the suckers are armed, which accounted for the injuries to these whales which had so long puzzled naturalists. A fight to the death between a Blue Whale, which sometimes grows to 100 feet long and weighs about a ton per foot of its length,

and an octopus, with eight powerful limbs each 20 or 30 feet long, must have been a fearsome affair.

One recalls a dramatic description, in *The Toilers of the Sea*, of a fight between an octopus and the hero of that story; but it would tax a super Victor Hugo to do justice to a fight between the largest of the mammals and the largest of the molluscs.



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